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Hamlin, Kenneth L.
Elk population dynamics and breeding biology, Gravelly-Snowcrest

y - Snowcrest Mountains

# ELK

# POPULATION DYNAMICS and BREEDING BIOLOGY

Progress Report • 1990 •

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JOB PROGRESS REPORT
RESEARCH PROJECT

State: Montana

Project No.: W-120-R-21
Project Title: Statewide Wildlife Research

Program No.: 1
Program Title: Big Game Research

Study No.: BG-3.1
Study Title: Elk Ecology Studies

Job No.: 1
Job Title: Elk Population Dynamics and Breeding Biology

Period Covered: July 1, 1989 - June 30, 1990

Prepared by: Kenneth L. Hamlin

Michael S. Ross
Michael S. Ross

Approved By: Terry N. Lonner
John P. Weigand
Donald A. Childress

Date: December 31, 1990

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

## OBJECTIVE

Assist with the compilation and evaluation of existing data bases on several elk herds in Montana. Coordinate and recommend research and management studies and procedures which will provide for more effective management and a better understanding of elk population dynamics.

## METHODS

Published and unpublished data continued to be compiled and evaluated. Meetings with MDFWP biologists, wildlife managers, and planners were continued to obtain their viewpoints and knowledge. This information will continue to be synthesized with the aid of the computer programs SAS, POSIM (Mooney and Lonner 1978), and TELDAY (Wildlife Div., MDFWP 1986) to better organize existing databases and evaluate elk management in Montana.

## RESULTS AND DISCUSSION

Coordination with Montana Department of Fish, Wildlife and Parks' biologists and game managers was continued to address future management and research needs for elk.

Data gathered by Kenneth R. Greer during the reduction of the Northern Yellowstone Elk Herd in the 1960s were organized for computer analysis and keying in of these data was completed. These data are from approximately 2,700 elk killed by personnel from the National Park Service and examined by Greer. Analyses of these data has not started.

Together with Rich DeSimone, a 27 page "white paper" entitled: "Probable effects of elk hunting regulations based on information collected from the Elkhorn and Gravelly Mountains" was prepared and given to Game Managers and Helena staff.

Input was given on improving terminology associated with elk habitat management at a 2-day meeting at Lubrecht Forest headquarters. In attendance were employees of the Montana Department of Fish, Wildlife and Parks, Idaho Fish and Game Department, U.S. Forest Service, the University of Montana, the Bureau of Land Management, and other agencies.

## RECOMMENDATIONS

This aspect of the overall study should be continued in accordance with the objectives and methods stated in the 1988-1992 Application for Federal Aid for this research effort.

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Wildlife Division. 1986. TELDAY user's manual. Montana Department Fish, Wildl. and Parks, Helena. In Revision.

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# INTRODUCTION

Elk (*Cervus elaphus nelsoni*) management in Montana has been primarily directed toward increasing elk numbers and maintaining a diversity of choice in elk hunting opportunity. In earlier years, diversity of choice was maintained by either-sex elk hunting. In 1963, 67% of Montana's hunted elk habitat was open to season-long either-sex hunting. More recently, season-long either-sex hunting has declined (to 1% of elk habitat by 1985) and diversity of choice has been maintained by a diversity of regulations among hunting units.

The any antlered bull regulation has remained widespread, but an increasing number of hunting units have been restricted to branch-antlered bull hunting. In 1981, only one hunting district (HD 324) was restricted to branch-antlered bull harvest. By 1985, 7 hunting districts had branch-antlered bull regulations and 2 were branch-antlered bull after an either-sex quota was reached. In 1989, 28 hunting districts and portions of 2 others had branch-antlered bull regulations.

Depending on the area, the branch-antlered bull regulation resulted either from concern over the long-term biological effects of yearling bulls siring most of the calves or from some hunters wanting to harvest a larger bull. Prior to implementation of this regulation, the MDFWP cautioned hunters that few bulls older than 2 years of age would be harvested.

Low observed calf:cow ratios in the Gravelly-Snowcrest Mountains during the winters of 1979-80 and 1980-81 (18-35 calves:100 cows versus 55-68:100 during 1970-75, Chrest and Herbert 1980 and 1981), coincided with low antlered bull:cow ratios. Available evidence suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival and population size (Hines and Lemos 1979, Prothero et al. 1979, and Smith 1980). Concern over the observed low calf:cow and bull:cow ratios resulted in changes in hunting regulations in HD 324 during 1981. The early archery season was eliminated, and the kill during the general elk season was limited to branch-antlered bulls. The branch-antlered bull regulation was also implemented in HDs 323, 326, and 330 during 1983 and HD 325 and the northern portion of HD 327 during 1987. The early archery season was restored in HD 324 during 1988.

This study was initiated in January 1984 to assess the role and importance of various hunting strategies on elk population characteristics and dynamics. Emphasis has been directed toward breeding biology, reproductive success, calf recruitment, seasonal distribution, movements, and habitat use. Effect of various hunting strategies on hunter success, attitudes, and other factors was also evaluated.

A new hunting regulation, the brow-tined bull regulation, will be implemented in 1990. This report will attempt to summarize information through the end of the branch-antlered bull period and, where warranted, draw conclusions about the effects of that regulation on the elk herd and hunters. This will also establish the baseline for evaluation of the brow-tined bull regulation.

## OBJECTIVES

1. Determine the effects of alternate hunting regulations and harvest rates on elk population dynamics and habitat use.

2. Test the hypothesis that when mature bulls (2+ years) comprise less than 5% of an elk population during the breeding season, the net reproductive success will be less than when compared to when the population has greater than 5% mature bulls.

3. Assist biologists with evaluation of existing elk population data and utilize the results from this study to better understand elk population dynamics and manage harvests.

## STUDY AREA

Because of low observed calf:cow and bull:cow ratios, the popularity of the area for hunting, and the changes in hunting regulations already in place, the Gravelly-Snowcrest Mountains in southwestern Montana were selected as the primary study area. In 1984 and 1985, work was concentrated on elk that winter on the Madison-Wall Creek Game Range (WCGR) south of Ennis. Elk that winter in the Cherry-Morgan area just north of Wall Creek were also captured and marked. The physiography and vegetation of this area have been described by Eustace (1967) and Gniadek (1987).

In 1986, work was expanded to include elk that wintered on the Blacktail Game Range (BTGR) southeast of Dillon. In spring 1989, study was expanded by marking elk that winter on the Robb-Ledford area, the Warmsprings area, and the Basin-Sage Creek area (Hamlin and Ross 1990). The expanded study primarily involves current MDFWP hunting districts 323, 324, 325, 326, 327 and 330 (Fig. 1).

Monthly normals for precipitation and temperature from 4 weather stations surrounding the Gravelly-Snowcrest complex are presented in Figure 2. Lakeview and Virginia City most

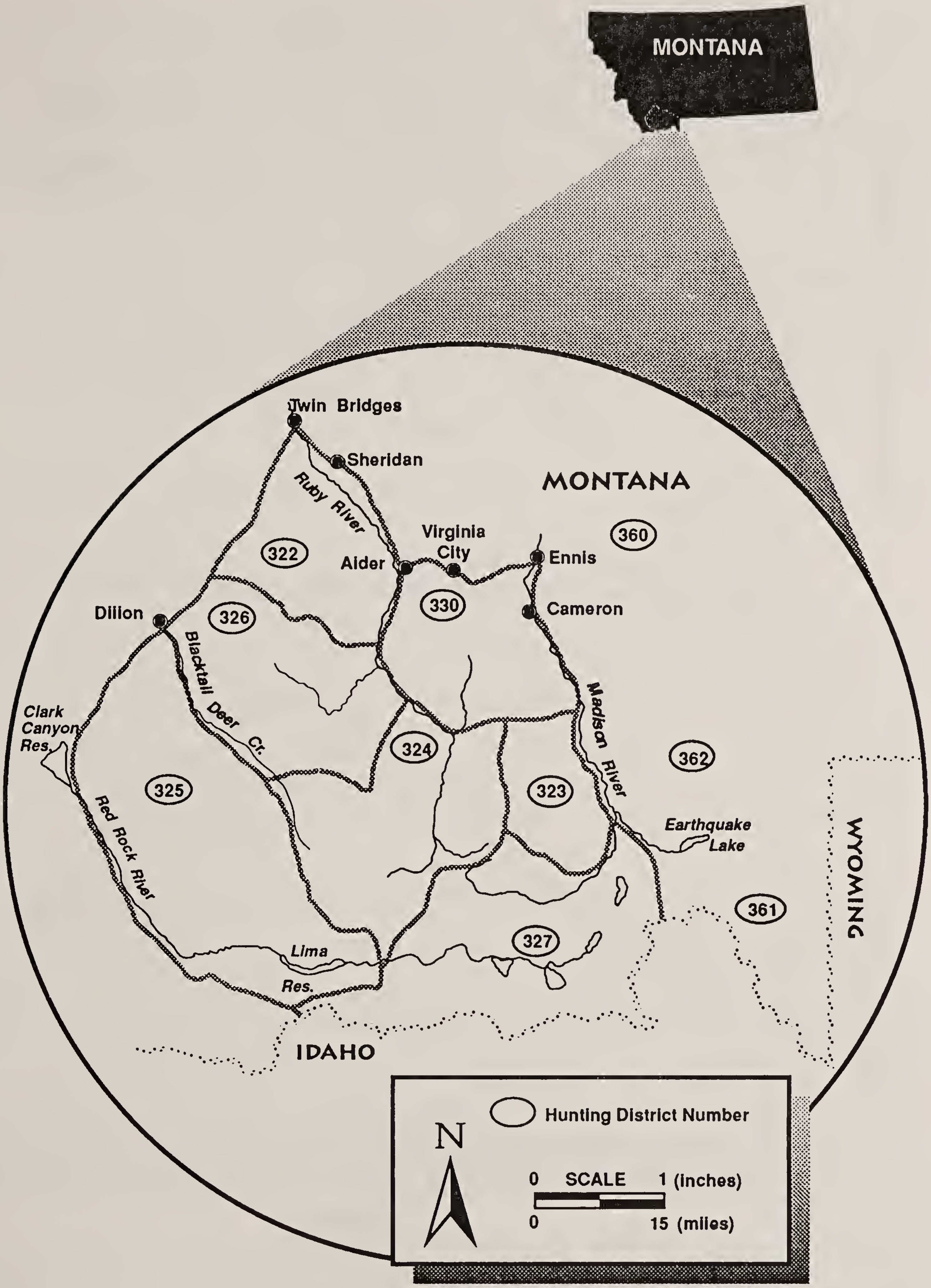


Figure 1. Location of hunting districts within the Gravelly-Snowcrest Study Area.

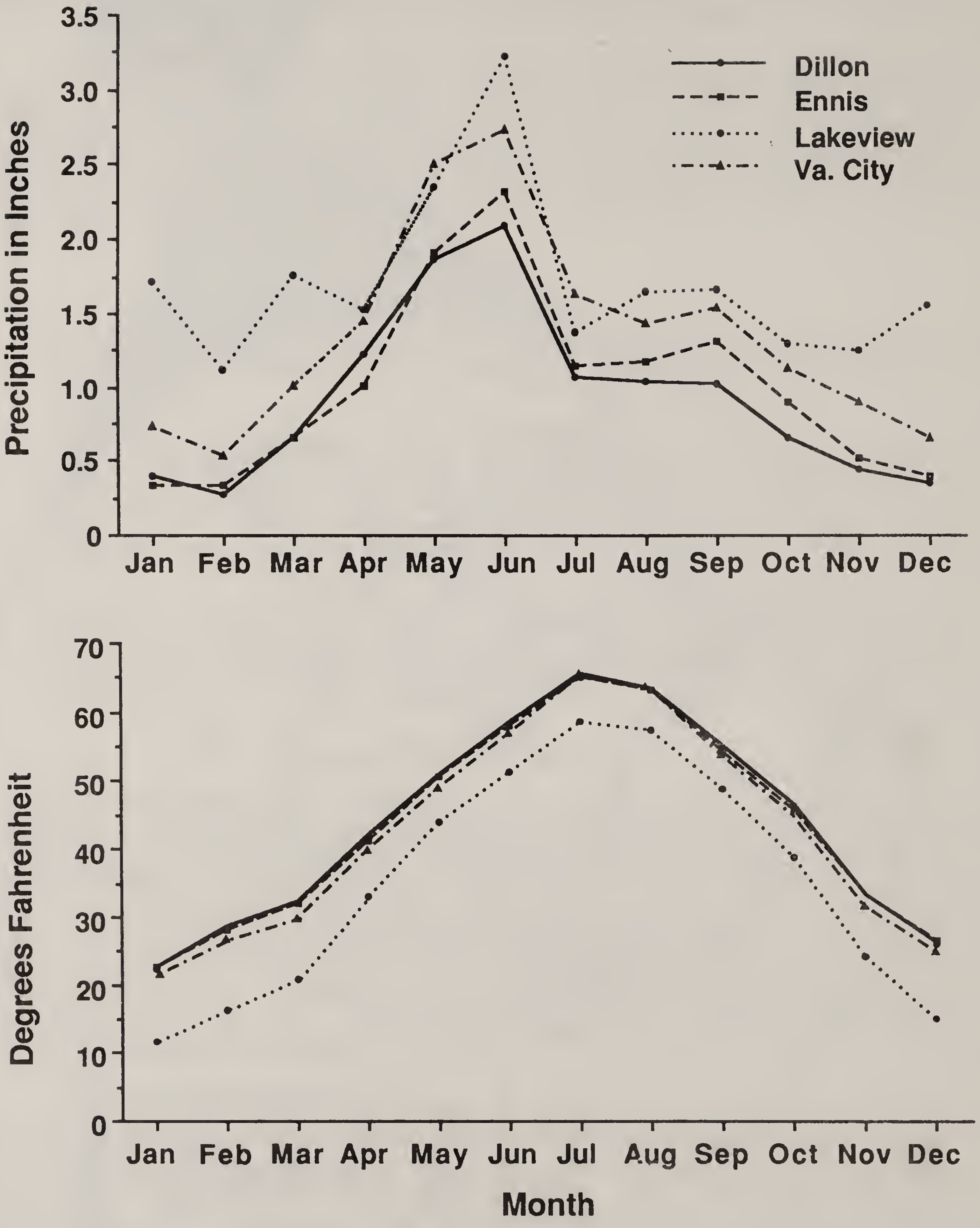


Figure 2. Monthly normals for precipitation and temperature at four weather stations surrounding the Gravelly-Snowcrest complex, 1951-80.

closely represent summer range conditions, and Dillon and Ennis most closely represent winter range conditions. As is typical for many Montana areas, precipitation peaked in June and temperature in July. Precipitation was lowest during February and temperature was lowest in January. Summer range was characterized by higher winter precipitation and lower yearlong temperatures than winter range.

Comparative trends in annual precipitation (Fig. 3) and temperature (Fig. 4) for 5 weather stations are presented for the period 1959-1989. Precipitation was generally below average during recent study years, and temperatures appeared to have fluctuated more widely than usual. Other major trends were not obvious.

## METHODS

Methods employed were similar to those reported previously (Lonner and Schladweiler 1987, Hamlin and Ross 1990).

During February 1990, capture of 135 elk (73 at WCGR and 62 on the BTGR) was accomplished by helicopter drive-netting. In order to study the extent of probable illegal mortality on yearling males we attempted to concentrate capture effort on male and female calves. We were successful at increasing the percentage of total calves captured, thereby reaching our number goal for male calves. In past trapping operations, random capture resulted in an average of 33% (range 18-45%) calves among captured animals. During 1990, 73% of captured animals were calves.

A total of 22 male and 27 female calves were captured on the WCGR and 23 male and 27 female calves on the BTGR. Forty-four of the male calves were equipped with black- or brown-colored radio-transmitter collars. Additionally, 21 adult females and 3 yearling males were captured on WCGR and 11 adult females and 1 yearling male on the BTGR. Three yearling males were equipped with radio-transmitter collars as were 12 adult females. Thirty-seven animals were fitted with neckbands and eartags. Four female calves on the WCGR and 22 on the BTGR were released with eartags only. Also, 10 adult females on the WCGR and 2 adult females and 1 male calf on the BTGR were released with only eartags.

Incisors were collected from elk older than 2 years during 1989-90 at check stations or from other mortalities. Age was assigned based on cementum analysis (Gilbert 1966) and compared to ages assigned by eruption-wear (Quimby and Gaab 1957).

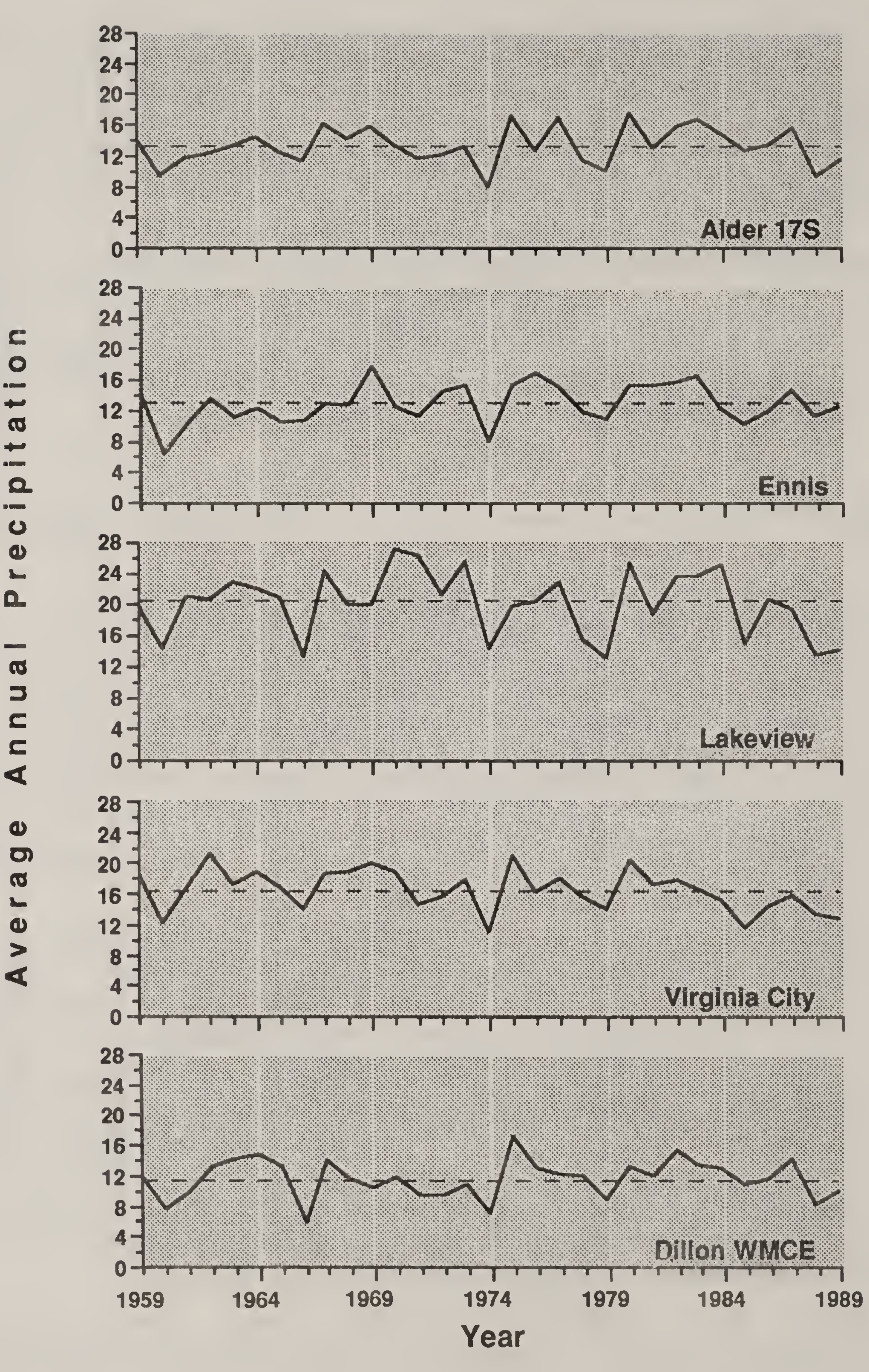


Figure 3. Annual precipitation in inches at five weather stations surrounding the Gravelly-Snowcrest Mountains, 1959-89.

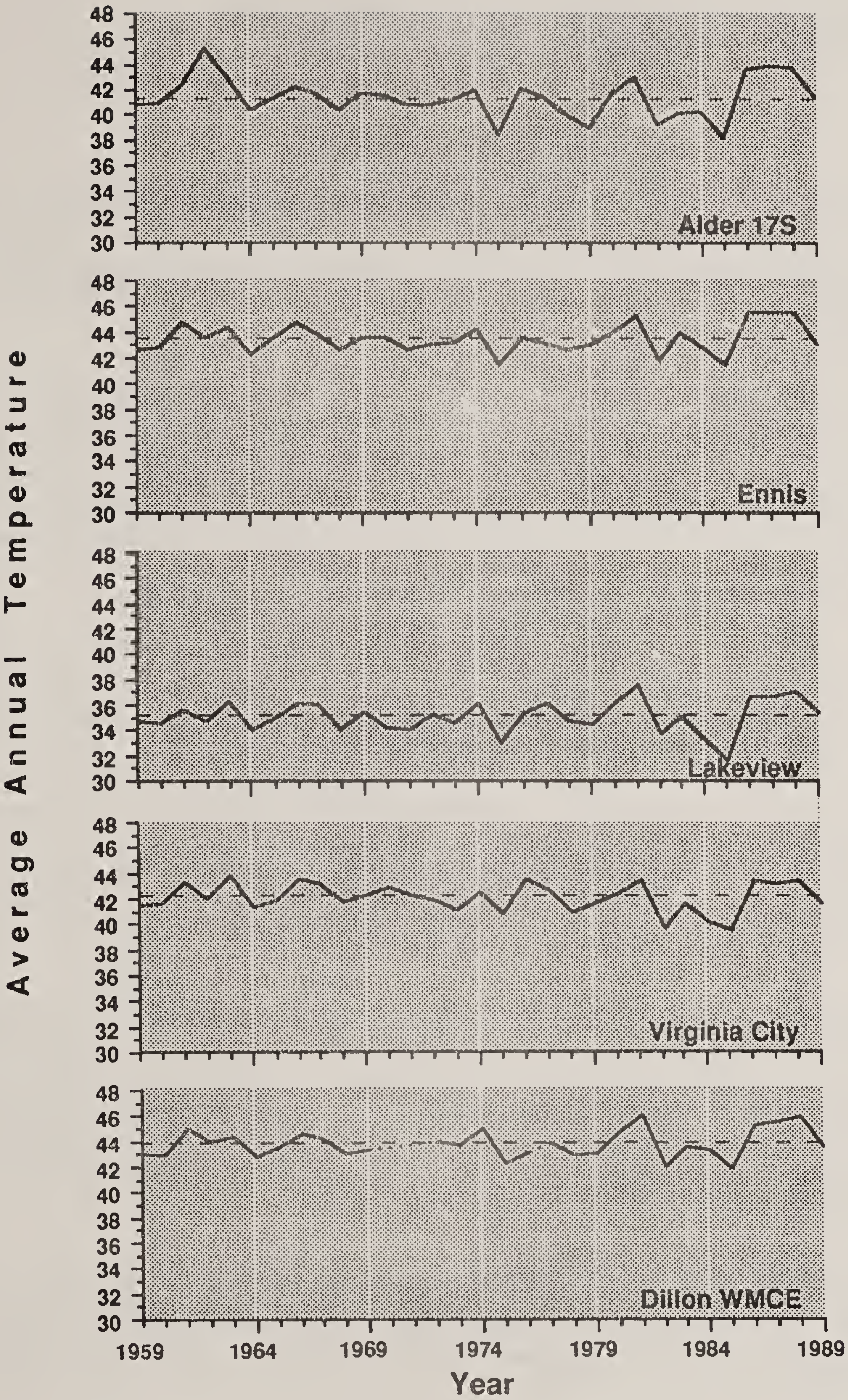


Figure 4. Average annual temperature (degrees Fahrenheit) at five weather stations surrounding the Gravelly-Snowcrest Mountains, 1959-89.

# RESULTS AND DISCUSSION

## Population Characteristics

### Numbers

Our aerial counts from a Piper Super Cub result in fewer animals counted than are actually present. The counts do represent minimum numbers present, however, and conducted over a long series of years, the trend counts accurately reflect the trend of the general population.

The presence of marked animals would usually indicate that mark-recapture census estimates (Lincoln Indexes) might be applicable here. They would allow upward adjustment of the census to account for animals missed during aerial surveys. On this area, however, the commonness of large groups of 300 to 1,000 elk reduces the reliability of mark-recapture census. It is difficult to accurately determine the presence or absence of particular animals within large groups.

At present we continue to rely on unadjusted aerial counts on these relatively open winter ranges as our best estimate of numbers. We recognize that these numbers are minimal, but to date, have not determined valid adjustment factors. Multiple counts at different times of the winter appear to offer refinement possibilities and will be pursued. Because of annual variation in timing of movement of elk to winter range, surveys during early winter appeared to underestimate elk numbers to a greater degree than mid-winter surveys. Similarly, surveys flown too late in winter may miss elk that have begun movement away from winter range.

Trends in numbers of elk observed during aerial surveys from 1947 to the present on the WCGR area and from 1948 to the present on the BTGR area are presented in Figure 5. Multiple counts, including both those made by research and management biologists at different times of the winter, are included from 1982 through the present. The lower estimates generally represented counts made before February.

Regardless of the accuracy of individual estimates, the portrayed long-term trend of increasing numbers is real. For both areas, the general increasing trend was closely tied to acquisition of winter range areas by MDFWP: 1960 for WCGR and 1972 for BTGR.

Counts by area on research surveys 1984-85 through 1989-90 (Table 1) also indicated an increasing population trend. A 1989-90 winter population of more than 6,000 elk for the Gravelly-Snowcrest complex was indicated. The actual annual rate of increase for the entire Gravelly-Snowcrest population

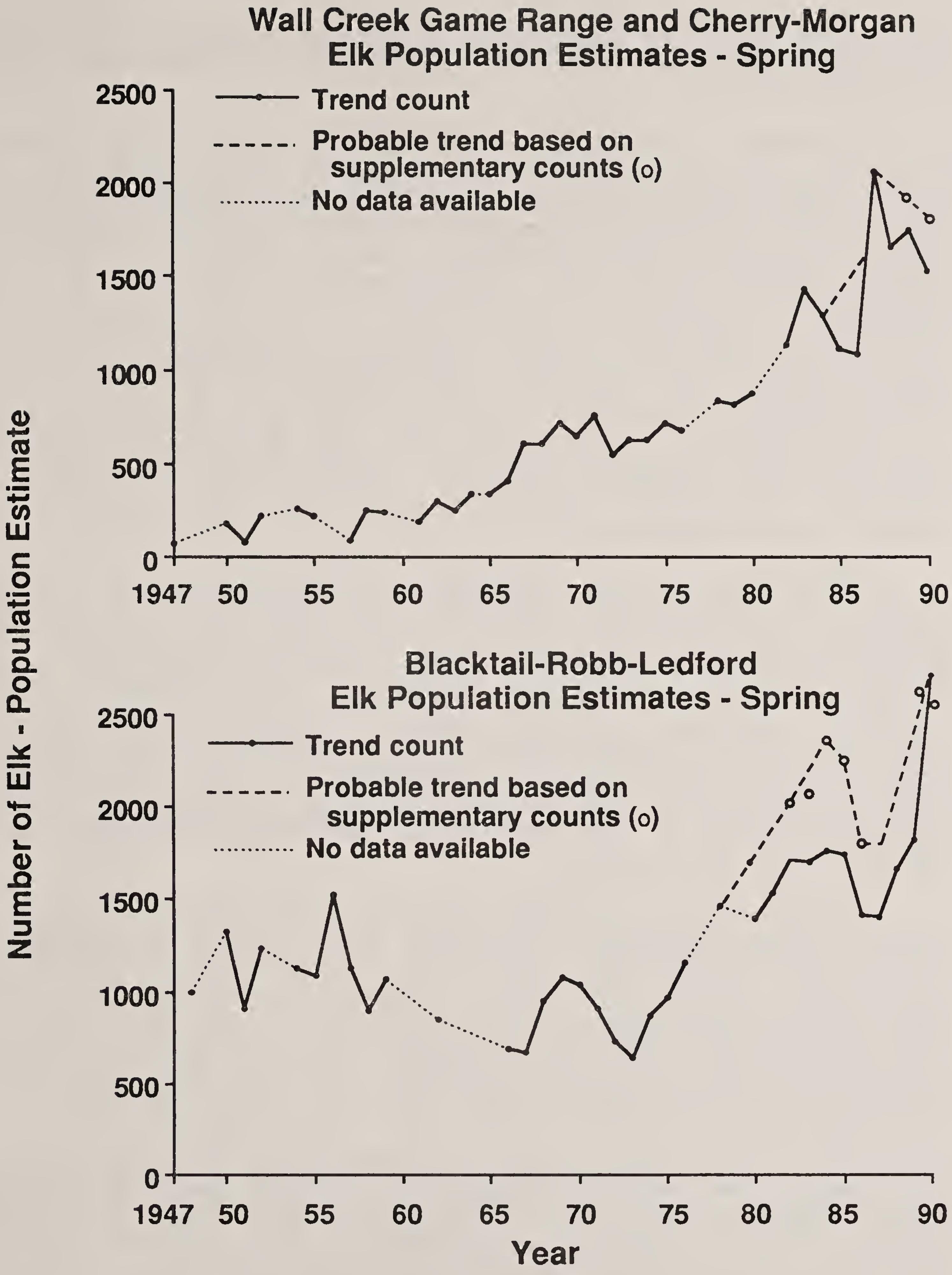


Figure 5. Trends in numbers of elk observed during winter aerial surveys of the Wall Creek Game Range area and the Blacktail-Robb-Ledford Game Range area, 1947-90.

was not as great as portrayed in Table 1 because additional areas were surveyed in recent years as we learned more about elk distribution.

A method of estimating population size using harvest estimates and ratios, mortality rates of marked animals, and sex and age classifications was attempted. This method used harvest data from statewide questionnaires adjusted to reflect sex and age structure recorded at check stations. Estimated annual harvest rates of adult females, adult males, and yearling males based on transmitter-collared animals was also necessary. Reported legal harvest for Gravelly-Snowcrest hunting districts was divided by hunting mortality rate of the marked sample for each sex-age category to provide a pre-season population estimate. The post-season estimate was made by subtracting reported legal kill and estimated crippling loss from the preseason estimate. Post-season bull and calf numbers were also estimated by use of post-season classification ratios.

Total post-season numbers of elk estimated in the Gravelly-Snowcrest complex by this method were 7,358 during 1989-90, 6,293 during 1988-89, and 5,058 during 1987-88. These estimates follow the trend indicated by total count surveys (Table 1) but are higher. If accurate, these estimates indicated the efficiency of aerial surveys to have been 82%, 76%, and 88% for 1989-90, 1988-89, and 1987-88, respectively. The lowest efficiency was for the first flights made on the area by the new researchers. Although there are probable errors in the population estimates provided, they appear to be reasonable.

The presence or absence of elk and the numbers counted on various areas appeared to depend upon timing of migration relative to survey time and weather conditions at the time of the survey. Thus, elk may not move into the Axolotyl Lake area until late winter and elk remained in the West Fork of the Madison area later during milder winters. Also, a portion of Cherry-Morgan and Wall Creek elk moved between both wintering areas depending upon time of winter and year.

Similar to Wall Creek and Cherry-Morgan populations, there was an unquantified degree of movement between the BTGR and the Robb-Ledford area. Information based upon the recent marking of elk in the Basin-Sage Creek area indicated that elk wintering in the South Centennial Valley and those in Basin-Sage Creeks are probably the same population. More of this population may winter in the South Centennials during milder winters. Censuses may become relatively more accurate now that most population segments for the entire Gravelly-Snowcrest complex have been identified. Those interchanging

Table 1. General locations of elk observations and counts for the winters of 1984-85 through 1989-90.

| | 1984-85 | 1985-86 | 1986-87 | 1987-88 | 1988-89 | 1989-90 |
|---|---|---|---|---|---|---|
| Axolotl Lake Area | 33 | 97 | 80 | 14 | 0 | 0 |
| Cherry-Morgan Creeks Area | 414 | 150 | 623 | 233 | 260 | 512 |
| Madison-Wall Creek Game Range | 664 | 805 | 1,233 | 1,182 | 1,401 | 880 |
| Missouri Flats-West Fork Madison | ---[a] | 35 | 134 | 132 | 91 | 157 |
| Total for east side of Gravellys | 1,111 | 1,087 | 2,070 | 1,661 | 1,752 | 1,549 |
| North Centennial Valley | 57 | 19 | 62 | 57 | 0 | 0 |
| South Centennial Valley | --[a] | ---[a] | ---[a] | ---[a] | ---[a] | 310 |
| Blacktail Game Range & Robb-Ledford Creeks | 1,740 | 1,416 | 1,403 | 1,663 | 1,820 | 2,719 |
| Greenhorn Mtns. & Lower Ruby River | ---[a] | 323 | 432 | 463 | 317 | 458 |
| Little Sage-Basin Creeks Area | ---[a] | 199 | 365 | 322 | 490 | 537 |
| Blacktail Ridge | ---[a] | ---[a] | 189 | 273 | 425 | 493 |
| Total for Blacktail-Centennial-Greenhorn Area | 1,797 | 1,957 | 2,451 | 2,778 | 3,052 | 4,517 |
| Grand Total | 2,908 | 3,044 | 4,521 | 4,439 | 4,804 | 6,066 |

[a] No flights were made over these areas

population segments must be censused on the same day to avoid either under- or overcounts owing to elk movements.

## Sex and Age Structure

### Classifications

Low production/survival of calves and low numbers of bulls observed on the Blacktail Game Range during spring 1980 (Fig. 6) resulted in hunting season changes and initiated this investigation. After 1980, calf:100 cow ratios improved gradually to around 50:100. That level remained lower than ratios of 55-78:100 observed during the late 1960s and early 1970s (Fig. 6).

Some question exists, however, about the validity of these earlier classifications. Samples were generally small, and often only portions of groups were classified. Observations during recent years have indicated severe problems with small samples and partial classifications. Distribution of calves both among and within groups is often very inconsistent. Thus, one group may have many more calves than another, and within larger groups many calves may be aggregated rather than evenly distributed. Small samples and partial classifications often lead to widely different results than those from complete classifications. Also, partial classifications of groups have a tendency to increase the percentage of easily classified animals, thus often increasing the percentage of calves and bulls reported. We probably cannot rule out the possibility that calf production/survival during the late 1960s and early 1970s was within the same range as observed during the last 3 years.

It appeared unquestionable that both total bulls and branch-antlered bulls (BAB) observed on the BTGR have increased since 1980 (Fig. 6), coinciding with implementation of the BAB regulation. Total bulls as a percentage of the total population is as high or higher now than during the late 1960s and early 1970s. From 1982 to 1990, total bulls observed in late winter populations have averaged 8.5% of the population. During 1980 and 1981, bulls were about 1.5% of the population. The high percentage of BABs observed during 1973-75 may be related to problems with small samples and partial classifications as discussed earlier for calf:100 cow ratios.

Similar conclusions and cautions apply to data collected on the Wall Creek Game Range (Fig. 7). During spring 1980, 87 calves:100 cows were observed on the WCGR at the same time that 24:100 were observed on the BTGR (Fig. 6). The fact that it is almost impossible for calf production to be this high and that only 220 elk were classified result in the conclusion

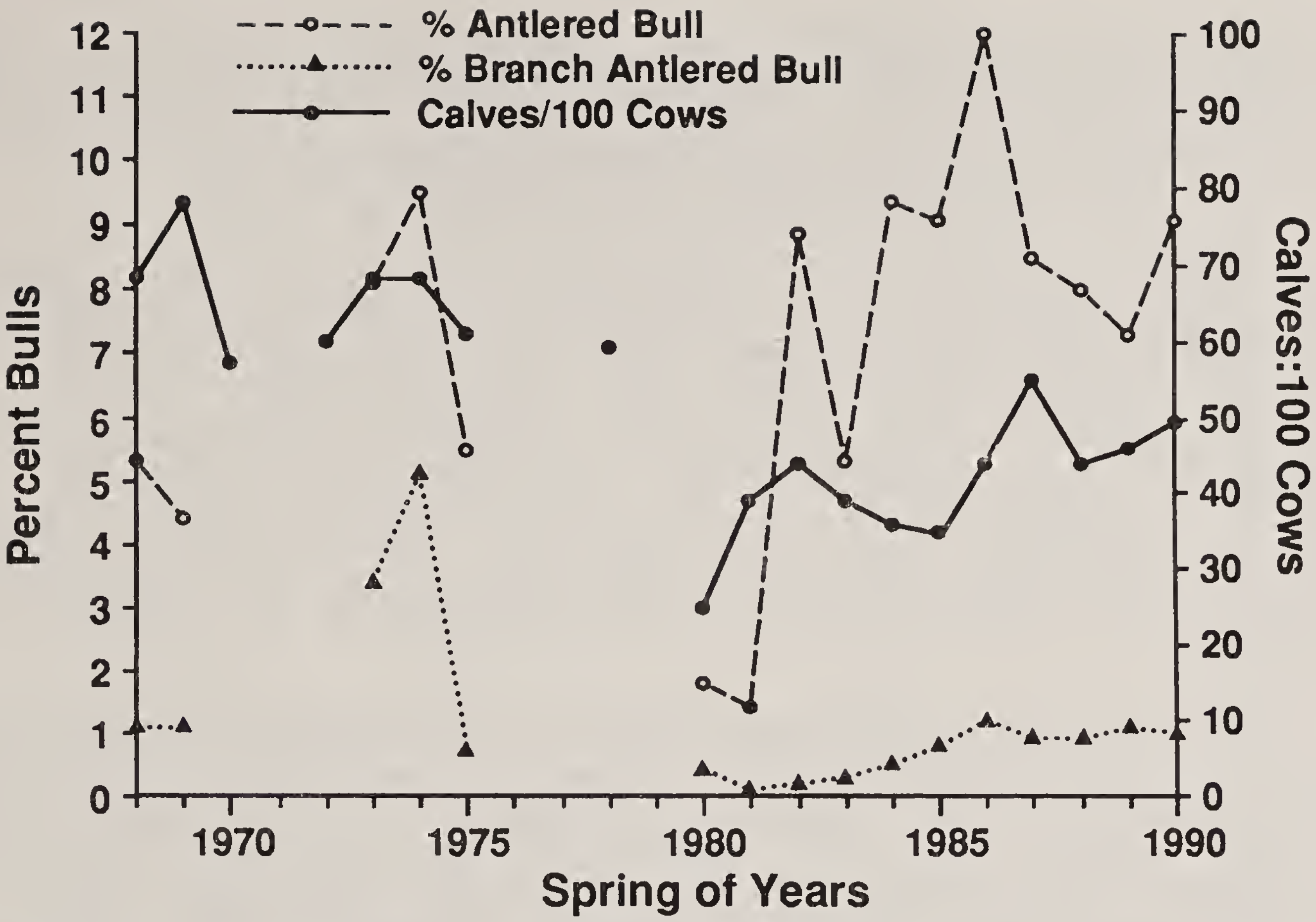


Figure 6. Sex and age structure of the elk population on the Blacktail Game Range, spring 1968-90.

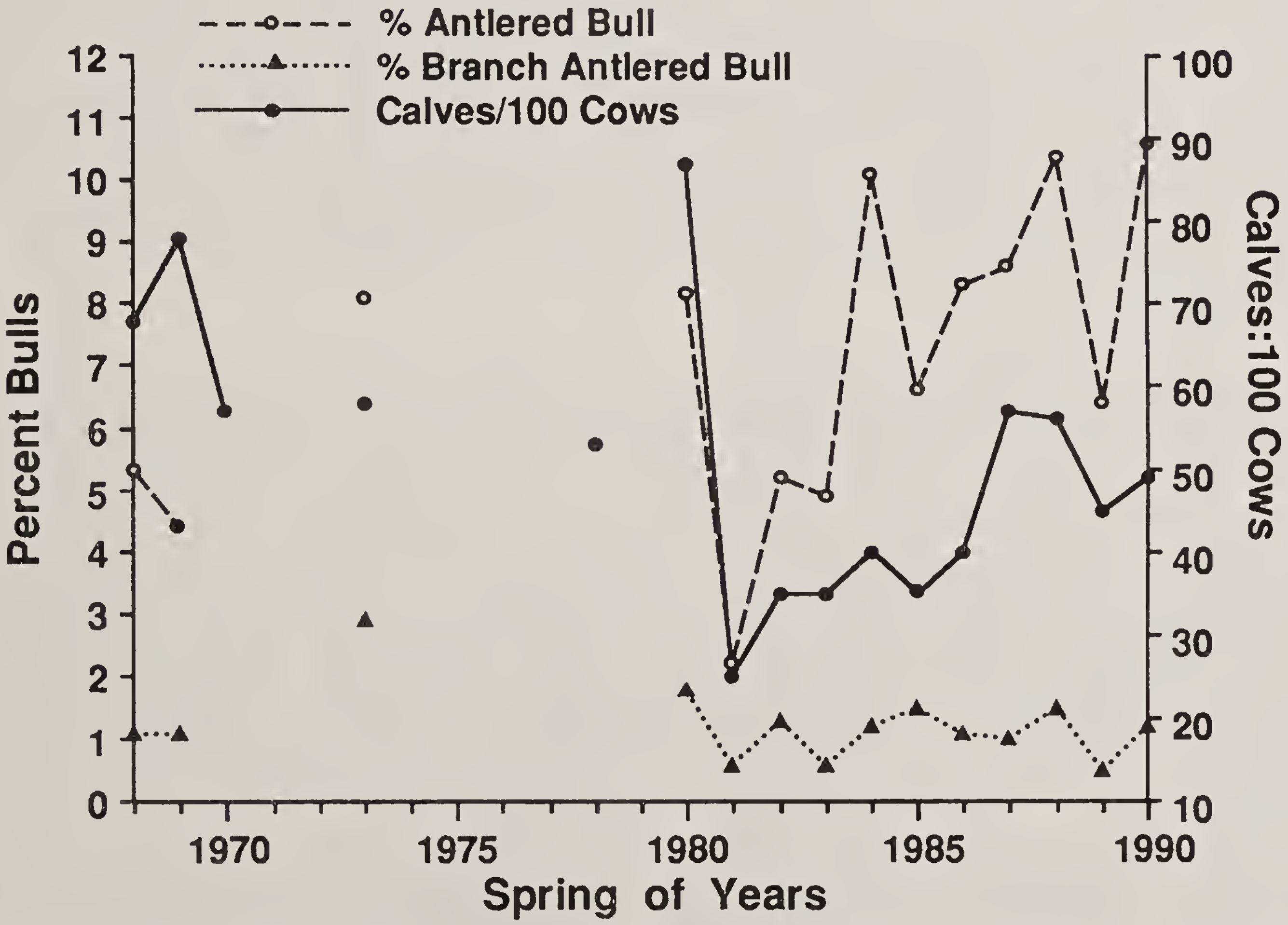


Figure 7. Sex and age structure of the elk population on the Wall Creek Game Range, spring 1968-90.

that both calf production and percentage total bulls were probably substantially overestimated at the WCGR in 1980. Calf production/survival increased steadily after spring 1981 (Fig. 7), recently reaching levels around 50:100.

Implementation of the BAB regulation in HD 323 during autumn 1983 resulted in a subsequent increase in total bulls observed on the winter range (Fig. 7). The percentage of the population comprised of BABs was not affected. Both total bulls and BABs on the WCGR were a higher percentage of the population than on the BTGR, even during 1980-81. That probably occurred because more of HD 323 than HD 324 is timbered, rugged, and inaccessible. This natural habitat security and lesser hunter access resulted in greater bull escapement.

Data for bulls were expressed as percentage of the total population in Figures 6 and 7 because that allowed display of additional data for some early years. During those years, cows and calves were not separated and only classified as antlerless. Data are also displayed as bull:100 cow ratios (Fig. 8) for comparison with other areas. Total bulls:100 cows on winter range has varied between 10 and 20 since 1983.

The calf:100 cow ratio reported here (35:100) for spring 1985 (Figs. 6 and 7), is lower than indicated in past reports (64-66:100). This change was made because proportions of yearling females in the harvest during autumn 1985 did not closely match those predicted by spring classifications. Proportions of yearling females in the harvest more closely matched predictions of spring classifications in other years (Table 2). The match of classification and age structure data during other years lends credence to observed values of both parameters.

Sex and age classifications made during July (Table 3) indicated relatively stable calf production and survival among years during 1984-90. Because of their short antlers at this time, many yearling males could not reliably be distinguished from cows during these aerial classifications, and ratios are reported as calves:100 cows + spikes. The calf:100 cows + spikes ratio reported in Table 3 convert to calf:100 cow ratios ranging from 50-60:100. These ratios many be slightly inflated because flights disproportionately sampled nursery groups. Similarly, BABs are probably underestimated as a percentage of the population because they often occurred as singles and small groups away from the nursery areas. Overall, however, relatively stable calf production and survival through late July was indicated for 1984-1990.

Sex and age classifications, including those made by Bob Brannon, for 6 different wintering areas during winter-spring

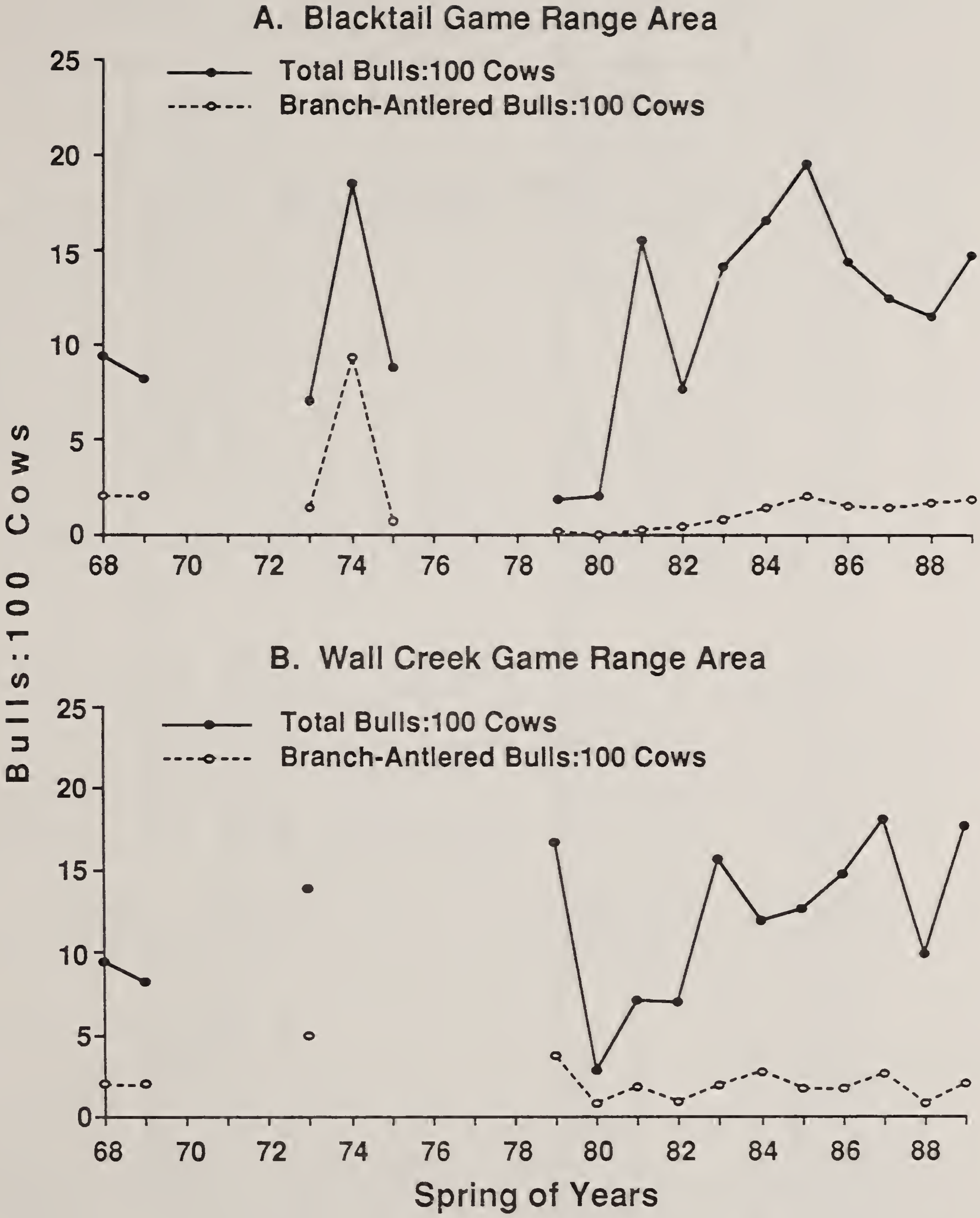


Figure 8. Sex ratios expressed as total bulls:100 cows and branch-antlered bulls:100 cows for A. the Blacktail Game Range area and B. the Wall Creek Game Range area.

Table 2. Estimated percent yearling cows in autumn populations based on spring classifications and estimated calf:100 cow ratios the previous spring based on age structure of the female harvest, 1984-89.

| | Calves:100 cows Spring classification | Estimated % yearling cows in autumn population based on spring classifications[a] | Estimated % yearling cows in autumn population based on age structure of hunter harvest | Estimated calves:100 cows previous spring based on harvest age structure |
|---|---|---|---|---|
| 1984 | 38 | 16.0 | 17.7 | 43 |
| 1985 | 66 | 24.8 | 15.1 | 35 |
| 1986 | 42 | 17.4 | 18.8 | 46 |
| 1987 | 56 | 22.0 | 21.4 | 55 |
| 1988 | 50 | 19.9 | 22.8 | 59 |
| 1989 | 45 | 18.8 | 19.9 | 50 |

[a] The projected % yearlings in the autumn population based on spring calf:100 cow ratios is calculated in the following way:

spring 1984 - 38 calves:100 cows = 19 female calves:100 cows
summer-autumn 1984 19 yearling cows/119 total cows = 0.1597

Table 3. Comparison of classification data among the summers of 1984 - 90 for the Gravelly-Snowcrest Mountains (BABS = Branch-Antlered Bulls).

| | From the Air (July) | | | From the Ground | | |
|---|---|---|---|---|---|---|
| Year | Calves/ 100 Cows + Spikes | Percent Calves | Percent BABS | Calves/ 100 Cows + Spikes | Percent Calves | Percent BABS |
| 1990 (H)[a] | 43.1 | 30 | 2 | -- | -- | -- |
| 1989 (H) | 47.9 | 32 | 1 | -- | -- | -- |
| 1988 (H) | 46.3 | 31 | 1 | -- | -- | -- |
| 1987 (H) | 43.1 | 30 | 1 | -- | -- | -- |
| 1986 (FW) | 35.6 | 26 | 2 | -- | -- | -- |
| 1986 (H) | 49.6 | 33 | 2 | 49.0 | 31 | 5 |
| 1985 (FW) | 49.7 | 32 | 3 | 41.5 | 27 | 7 |
| 1984 (H) | 44.3 | 30 | 2 | 43.5 | 30 | 2 |

[a] FW= fixed wing, H = helicopter

1990 (Table 4) indicated similar levels of calf and bull survival among areas. Exceptions included unusually low calf:100 cow ratios in the Greenhorn Mountains and a lower percentage total bulls on the BTGR than elsewhere. However, more than half the elk on the BTGR were not classified during surveys made from the ground. Aerial census flights (Table 5) indicated a higher percentage of bulls than for classifications from the ground.

Although a few sub-legally branched yearlings may have been missed, the number of branched yearling bulls observed on winter range has been very low (Tables 4 and 5).

## Capture and Harvest

Classifications indicated that the sex ratio of adults was heavily slanted toward females (Figs. 6, 7, 8 and Tables 3, 4, and 5). This was not surprising given the heavy harvests of males that occur on this area. Sex ratios probably did not start out with females predominating (Table 6). Larger samples obtained by others in southwestern Montana indicated a nearly even sex ratio at birth (e.g. the Gallatin area, Johnson 1951, 96 males:100 females; and the Yellowstone area, in utero ratio = 93 males:100 females, MDFWP 1987).

Sex ratio of calves in the harvest (60 males:100 females) heavily favored females (Table 6). This same phenomenon was

Table 4. Classification results from ground observations in the Gravelly-Snowcrest Mountains, winter-spring 1990.

| Date | Total | Cows | Calves | Spikes | BABs | Calf/ Cow Ratio | % AB[a] | % BAB[b] |
|---|---|---|---|---|---|---|---|---|
| Wall Creek Game Range Area | | | | | | | | |
| 02/8-10/90 | 2,013[c] | 1,184 | 509 | 192(1)[d] | 19 | 43.0 | 10.5 | 0.9 |
| 02/8-10/90 | 666[e] | 393 | 192 | 70 | 11 | 48.9 | 12.2 | 1.7 |
| Blacktail Game Range Area | | | | | | | | |
| 03/12/90 | 821 | 515 | 255 | 45 | 6 | 49.5 | 6.2 | 0.7 |
| Blacktail Ridge | | | | | | | | |
| 03/14/90 | 320 | 197 | 88 | 44(2) | 1 | 44.7 | 14.1 | 0.3 |
| Robb-Ledford Area | | | | | | | | |
| 02/14/90[f] and 03/16/90 | 400 | 242 | 118 | 39(1) | 0 | 48.8 | 9.8 | 0.0 |
| Little Sage Creek | | | | | | | | |
| 03/21/90[f] | 460 | 281 | 135 | 42 | 2 | 48.0 | 9.6 | 0.4 |
| Greenhorns | | | | | | | | |
| 03/16/90[f] | 119 | 89 | 18 | 11 | 1 | 20.2 | 10.1 | 0.8 |

[a] AB = antlered bull
[b] BAB = branch-antlered bull
[c] Total classified in 3 days, includes duplication
[d] Total number of yearling males (number of 2x1+ yearling males)
[e] Includes only known best unduplicated classifications
[f] Classifications by Bob Brannon

Table 5. Classification results obtained during census flights, winter-spring 1990.

| Date | Total | Cows and Calves | Spikes | BABS[a] | % AB[b] | % BAB[a] |
|---|---|---|---|---|---|---|
| East Side of Gravellys including Madison-Wall Creek Game Range | | | | | | |
| 01-20-90 | 1,549 | 1,385 | 145 (1)[c] | 19 | 10.6 | 1.2 |
| 02-28-90[d] | 1,824 (1,243)[e] | 1,148 | 86 (1) | 9 | 7.6 | 0.7 |
| Greenhorn Mountains and Lower Ruby River (Warmsprings Creek) | | | | | | |
| 02-05-90 | 458 | 413 | 42 | 3 | 9.8 | 0.7 |
| 03-16-90[d] | 367 | 230 | 29 | 1 | 8.2 | 0.3 |
| Robb-Ledford Area | | | | | | |
| 02-05-90 | 697 | 632 | 59 (1) | 6 | 9.3 | 0.9 |
| 03-07-90[d] | 638 | 571 | 65 (2) | 2 | 10.5 | 0.3 |
| Blacktail Game Range Area | | | | | | |
| 02-05-90 | 2,022 (981)[e] | 894 | 76 | 11 | 8.9 | 1.1 |
| 03-07-90[d] | 1,908 | 1,754 | 139 (7) | 15 | 8.1 | 0.8 |
| Blacktail Ridge | | | | | | |
| 02-18-90 | 493 | 438 | 51 | 4 | 11.2 | 0.8 |
| 03-06-90[d] | 425 | 371 | 54 | 0 | 12.7 | 0.0 |
| Basin-Sage Creeks | | | | | | |
| 02-18-90 | 537 (422)[e] | 382 | 38 | 2 | 9.5 | 0.5 |
| 02-27-90[d] | 910 | 866 | 42 | 2 | 4.8 | 0.2 |
| South Centennial Valley | | | | | | |
| 02-18-90 | 310 | 301 | 9 | 0 | 2.9 | 0.0 |
| 03-06-90[d] | 323 | 316 | 7 | 0 | 2.2 | 0.0 |

[a] BAB = branch-antlered bulls

[b] AB = antlered bull

[c] Total number of yearling males (number yearling males 1x2+)

[d] Flights by Bob Brannon

[e] Total number counted (number classified)

Table 6. Observed sex ratio of elk calves captured and harvested in the Gravelly-Snowcrest Mountains during 1984-90.

| Newborn | Year | Male | Female |
|---|---|---|---|
| | 1984 | 12 | 8 |
| | 1985 | 5 | 3 |
| | 1986 | 12 | 9 |
| | 1987 | 3 | 6 |
| | 1988 | 8 | 6 |
| | | 40 | 32 |
| | | 125:100 | |
| Known Summer Deaths | | 8 | 3 |
| Remainder | | 32 | 29 |
| | | 110:100 | |

| Harvest | Year | Check Station | | Jaw Tags | | Total | |
|---|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | Male | Female |
| | 1984 | 14 | 18 | -- | -- | 14 | 18 |
| | 1985 | 13 | 23 | 12 | 20 | 25 | 43 |
| | 1986 | 12 | 20 | 7 | 18 | 19 | 38 |
| | 1987 | 16 | 29 | 11 | 16 | 27 | 45 |
| | 1988 | 12 | 28 | 8 | 23 | 20 | 51 |
| | 1989 | 27 | 32 | 14 | 17 | 41 | 49 |
| | | 94 | 150 | 52 | 94 | 146 | 244 |
| | | 63:100 | | 55:100 | | 60:100 | |

| Winter Trapping | Year | Male | Female |
|---|---|---|---|
| | 1984 | 7 | 9 |
| | 1985 | 8 | 22 |
| | 1986 | 4 | 5 |
| | 1987 | 3 | 4 |
| | 1988 | 23 | 23 |
| | 1990 | 45 | 54 |
| | | 90 | 117 |
| | | 77:100 | |

observed in the Yellowstone (63 males:100 females) and Gallatin drainages (83 males:100 females) (MDFWP files). Sex ratio of calves captured during February and March (77:100) were less "unbalanced" and, except for 1985, were not severely displaced from 1:1.

Caution must be used when interpreting these sex ratios. For the small sample we have, young males did die at higher rates than females (Table 6). However, there was no evidence that the ratio should be as unbalanced as that observed for hunter-killed calves. It is often difficult for check station attendants to sex field-dressed calves that also may be cut up or under camping gear or other animals. Often, we rely on the hunters opinion of the animals sex. Without the obvious antler bumps of male deer fawns, many male calves may be called females. We do know that captured elk calves have been mis-sexed and that all known cases were of males called females. It is likely that the sex ratio of 6-9 month old calves is less unbalanced than portrayed in Table 6, but further investigation is needed. Accurate determination of sex ratio is necessary to make accurate projections of expected population trends and bull survival rates.

Age structure of 1989 hunter-killed elk (Table 7) indicated few males in the population older than 3 years and sharply declining numbers of females older than 5 years. Comparison of incisor cementum annuli with ages assigned by eruption-wear at check stations and with a jaw board in the lab indicated differences. Ages assigned at check stations and in the lab based on eruption-wear tended to overestimate the number of 4-year-olds and underestimate the number of 3-year olds. Thirteen of 45 females aged 4 years by eruption-wear were 3 years as determined by cementum annuli. Eleven of 45 females aged 4 years by eruption-wear were 5-years-old as determined by cementum annuli. Similarly, 3 of 12 males aged 3 years by eruption-wear and 1 of 2 aged 4 years were one year younger as determined by cementum annuli. Also, if there was a discrepancy, elk older than 5 years tended to be under-aged by eruption-wear. Thus, a major discrepancy between eruption-wear and cementum annuli ages was at 4 years, indicating the possibility that jaws for that age on the laboratory jawboard did not match elk from the Gravelly-Snowcrest population. Further investigation of this phenomenon will be made, but other information also indicated that the number and percentage of 4-year-olds has been overestimated in the past, coinciding with an underestimate of the number of 3-year-olds.

Age of hunter-killed bull elk has tended to increase from 1984 through 1989 (Fig. 9). Because 2 fewer hunting units were open to harvest of spikes after 1986, most of this increase was related to changing hunting season structure. This reduced the percentage of yearlings harvested,

Table 7. Sex and age structure of elk checked at hunter check stations and of jaws left in jaw barrels during 1989.

| Age | Females | Males |
|---|---|---|
| ½ | (49)[a] | (41)[a] |
| 1½ | 19.9 (60)[b] | 20.7 (25)[b] |
| 2½ | 15.0 (45) | 62.8 (76) |
| 3½ | 14.9 (45) | 11.6 (14) |
| 4½ | 10.0 (30) | 1.7 (2) |
| 5½ | 11.0 (33) | 1.6 (2) |
| 6½ | 5.3 (16) | 0.8 (1) |
| 7½ | 5.3 (16) | 0.0 |
| 8½ | 5.3 (16) | 0.0 |
| 9½ | 2.0 (6) | 0.8 (1) |
| 10½ | 2.0 (6) | |
| 11½ | 2.3 (7) | |
| 12½ | 1.9 (6) | |
| 13½ | 1.3 (4) | |
| 14½ | 0.7 (2) | |
| 15½ | 0.7 (2) | |
| 16½ | 0.3 (1) | |
| 17½ | 0.3 (1) | |
| 18½ | 0.6 (2) | |
| 19½ | 1.0 (3) | |
| 20½ | 0.3 (1) | |
| uncl. ½ | (5) | |
| uncl. 2½+ | (13) | (2) |
| uncl. 3½+ | | (2) |
| No. 1½+ | (301+13)[c] | (121+4) |

[a] (Number of calves)

[b] % of 1½ and older animals checked (number checked)

[c] Including the unclassified 2+ adults, yearling females made up 19.1% of harvest instead of 19.9% and yearling males comprised 20.0% of the harvest instead of 20.7%

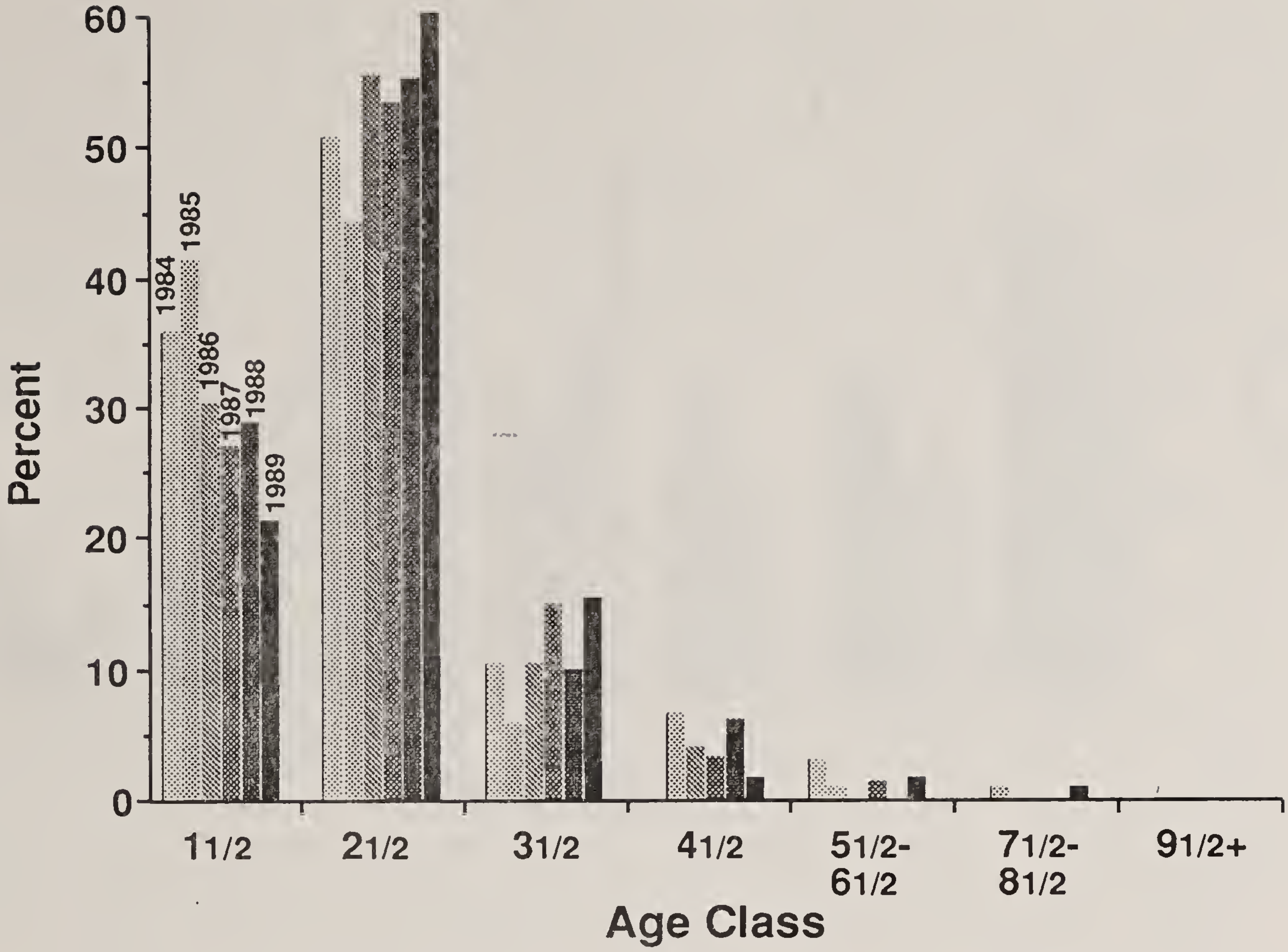
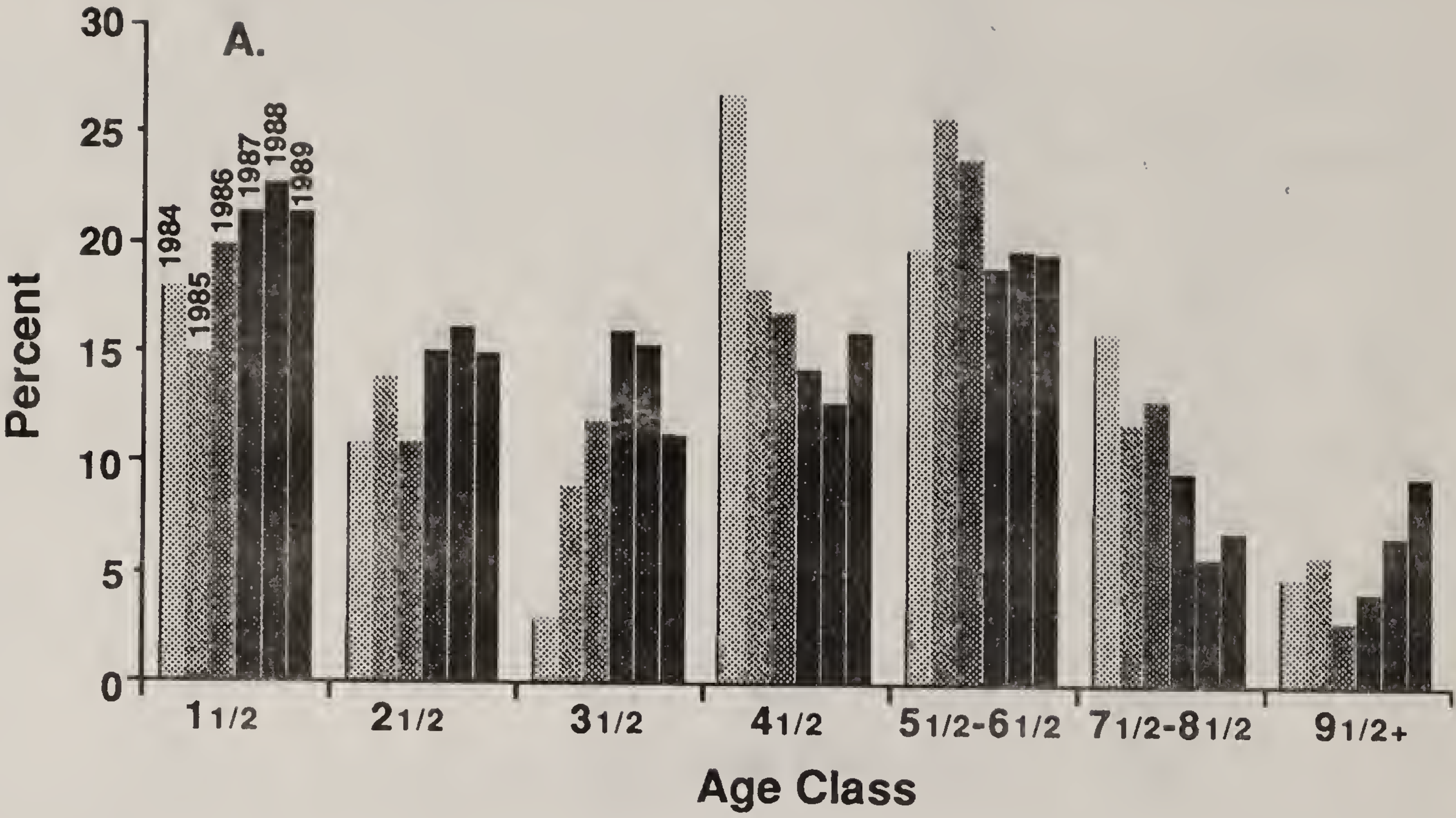


Figure 9. Age of hunter-killed bull elk, 1984-89, as recorded at check stations.

automatically increasing percentages for older animals even without an increase in numbers. Although there may have been a slight increase in 3-year-olds, the reduction in harvest of yearlings and the uncorrected over-aging of 3- and 4-year-olds discussed earlier casts some doubt on this possibility. Uncorrected data (Fig. 9) are presented to be consistent with past years. There was no evidence for an increasing number of bulls older than 3 years.

Age of yearling and older female elk harvested by hunters is presented in uncorrected (Fig. 10A) and corrected (Fig. 10B) versions. The uncorrected version indicated more 4-year-olds than 3-year-olds during most years, which cannot occur 2 years in a row without hunter selection for 4-year-olds or mis-aging. Previous discussion indicated mis-aging as the most likely cause.



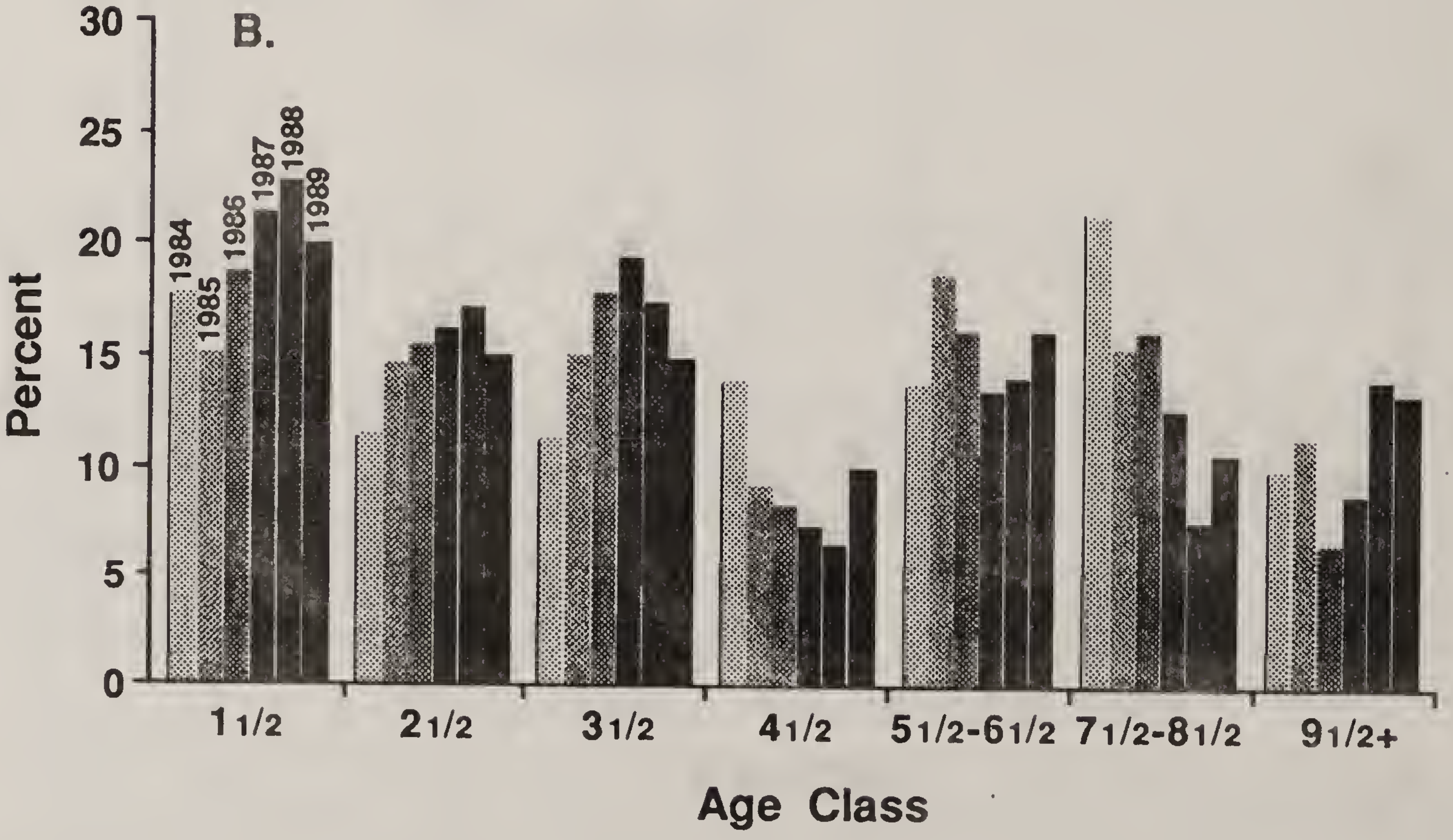


Figure 10. A. Uncorrected (see text) age of adult female elk 1984-89, recorded at check stations and from jaws turned in by hunter. B. Corrected (see text) age of adult female elk, 1984-89, recorded at check stations and from jaws turned in by hunters.

Because generally the same people worked at check stations each year and results using the laboratory jaw board were similar between previous and current researchers, we believed that this mis-aging was probably consistent among years and could be corrected. Corrections for all years based on results of 1989 cementum analysis (Fig. 10B) generally indicated increased numbers of 3-year-olds, decreased numbers of 4-year-olds, and an increase in older animals each year compared to the uncorrected version (Fig. 10A). Generally, the data (Fig. 10B) are consistent with the slow increase in calf:100 cow ratios observed in recent years and did not indicate major annual changes.

Calves were not included in displays of age structure based on hunter harvest because they were selected against by hunters and inclusion of them does not represent true population age structure. Calves:cow recorded at check stations (Table 8) ranged from 14-48 percent less than observed in field classifications. Even fewer calves were represented in jaws turned in by hunters at jaw barrels. The calf:cow harvest ratio reported on the statewide hunter questionnaire was only about half that recorded at check stations (Table 8). Similar results have been reported for deer (Hamlin and Mackie 1989). Hunters either are confused about the definition of a calf, don't know how to distinguish age, and/or are reluctant to admit killing calves.

Because this means that these calves are reported as cows or bulls, harvest figures by sex and age categories in the statewide hunter questionnaire must be adjusted when attempting to use them to model population dynamics. Possibly one of the reasons that many simulation models run out of bulls within a few years is that in addition to undercounts of bulls in surveys, the bull harvest is overestimated by questionnaires.

## Physical Characteristics

### Antlers

Antler characteristics of bulls from Gravelly-Snowcrest hunting districts checked at check stations and reported on the statewide hunter questionnaire are compared in Table 9. Generally, hunters appeared to report all antler points, including those less than one inch in length. Thus, check station data showed fewer 4x4 antlers and more 4x3 antlers, for example, than questionnaire data. Spikes shot in hunting districts where they were not legal have consistently been reported, but percentages may have declined in the last 3 years compared to 1985 and 1986. Bulls with 6 points on at least one antler have comprised about 14% of the harvest, and

Table 8. Number of calves, cows, and calf:cow ratio observed at check stations, from jaw tag returns, and reported on the statewide hunter questionnaire.

| Year | Check Station | | | Jaw Tags | | | Check Station and Jaw Tags | | | Statewide Hunter Questionnaire | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calf | Cow | Calf:Cow Ratio | Calf | Cow | Calf:Cow Ratio | Calf | Cow | Calf:Cow Ratio | Calf | Cow | Calf:Cow Ratio |
| 1984 | 32 | 112 | 0.29 | -- | -- | -- | 32 | 112 | 0.29 | 96 | 719 | 0.13 |
| 1985 | 37 | 131 | 0.28 | 32 | 144 | 0.22 | 69 | 275 | 0.25 | 122 | 709 | 0.17 |
| 1986 | 33 | 114 | 0.29 | 25 | 128 | 0.20 | 58 | 242 | 0.24 | 89 | 500 | 0.18 |
| 1987 | 45 | 152 | 0.30 | 31 | 132 | 0.24 | 76 | 284 | 0.27 | 67 | 606 | 0.11 |
| 1988 | 41 | 169 | 0.24 | 32 | 160 | 0.20 | 73 | 329 | 0.22 | 98 | 771 | 0.13 |
| 1989 | 59 | 142 | 0.42 | 36 | 172 | 0.21 | 95 | 314 | 0.30 | 123 | 721 | 0.17 |
| Total | 247 | 820 | 0.30 | 156 | 736 | 0.21 | 403 | 1,556 | 0.26 | 595 | 4,026 | 0.15 |

Table 9. Antler point characteristics of male harvest for Gravelly-Snowcrest hunting units 323, 324, 325, 326, 327, and 330 from check stations and the statewide hunter questionnaire.

| No. of Points | Check Stations | Statewide Hunter Questionnaire | | | | | |
|---|---|---|---|---|---|---|---|
| | 1984-1989 | 1985 | 1986 | 1987 | 1988 | 1989 | Total |
| 1x1 | 61 (11.0)[a] | 20-13[b] | 44-28 | 17-11 | 26-16 | 27-17 | 134-85 |
| 2x1 | 45 (9.3)[c] | 6 | 7 | 16 | 10 | 5 | 44 (4.4)[c] |
| 2x2 | 34 (7.0) | 12 | 34 | 35 | 23 | 40 | 144 (14.3) |
| 3x[d] | 1 | 1 | 1 | 1 | 1 | 0 | 4 |
| 3x2 | 15 (3.1) | 7 | 3 | 9 | 4 | 5 | 28 (2.8) |
| 3x3 | 7 (1.4) | 6 | 8 | 10 | 14 | 17 | 55 (5.5) |
| 4x | 4 | 1 | 0 | 0 | 1 | 2 | 4 |
| 4x3 | 25 (5.1) | 6 | 4 | 8 | 6 | 7 | 31 (3.1) |
| 4x4 | 52 (10.7) | 16 | 22 | 28 | 34 | 38 | 138 (13.7) |
| 5x | 5 | 0 | 0 | 0 | 1 | 5 | 6 |
| 5x4 | 68 (14.0) | 9 | 12 | 21 | 24 | 24 | 90 (9.0) |
| 5x5 | 153 (31.5) | 31 | 60 | 66 | 99 | 67 | 323 (32.1) |
| 6x | 4 | 0 | 0 | 1 | 0 | 1 | 2 |
| 6x5 | 26 (5.4) | 3 | 11 | 10 | 19 | 15 | 58 (5.8) |
| 6x6+ | 47 (9.7) | 5 | 12 | 18 | 26 | 18 | 79 (7.9) |
| Total No. | 547 | 123 | 218 | 240 | 288 | 271 | 1,140 |
| No. 2x1+ | 486 | 103 | 174 | 223 | 262 | 244 | 1,006 |
| No. illegal 1x1 (% of legal) | 4 (0.7) | 7 (6.0) | 16 (7.9) | 6 (2.6) | 10 (3.6) | 10 (3.8) | 49 (4.5) |

[a] Number (%) of total antlered males
[b] Total number 1x1 - Number 1x1 reported in legal districts
[c] Number (%) of 2x1 and greater from this point in the column downward
[d] Those with less points on one side than other listings in the table

bulls with 5 points on one antler and 5 or less on the other antler have comprised about 42% of the harvest.

Data from years and areas where all bulls were legal indicated that about 75% of yearling bulls were spikes (Table 10). Eleven percent of yearlings were 1x2, 8.5% were 2x2, and about 5% had 3 or 4 points on at least one antler. Most (71.9%) 2-year-old bulls had at least 5 points on one antler and 10% had 6 points on 1 antler. Of the few 2-year-olds with less than 4 points on an antler, several were known to be deformed owing to injury. Eighty-seven percent of 3-year-olds had 5x5 or greater antlers; 46% had at least 6 points on one antler. Bulls 4-years-of-age were relatively evenly divided between 5 and 6 points per antler and 82% of bulls 5 years and older had 6 points or more on each antler. Few bulls 5 years and older have been examined in the Gravelly-Snowcrest Mountains, but it is obvious that maximum antler size is not reached until at least 5-years-of-age.

The over-aging at check stations noted earlier may indicate that there are fewer points per side on 3-year-old bulls and more on 4-year-old and older bulls than presented here (Table 10).

The percentage of harvested branched-bulls with at least 6 points on one antler has not increased measurably since BAB regulations were implemented (Fig. 11).

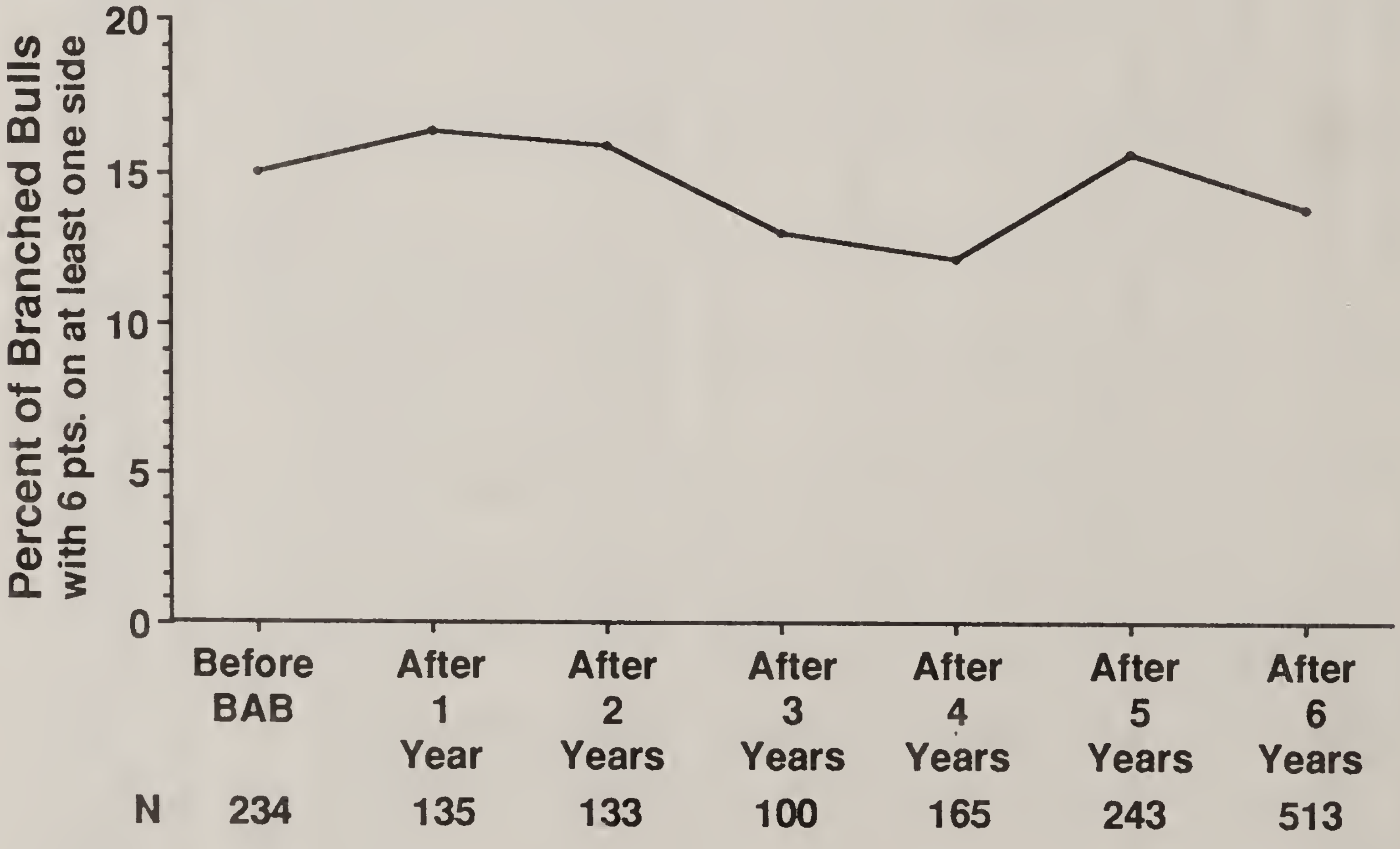


Figure 11. The percentage of branch-antlered bulls harvested with six points on at least one antler in relation to time since implementation of the BAB regulation.

Table 10. Antler classifications by age-class for male elk checked through Gravelly check stations, 1984-89.

| Male Age | Antler Classification | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1x1 | 1x2 | 2x2 | 1x3 | 2x3 | 3x3 | 1x4 | 2x4 | 3x4 | 4x4 | 2x5 | 3x5 | 4x5 | 5x5 | 4x6 | 5x6 | 6x6+ | Total |
| 1½ | about 75% of age class from districts where legal | 44 | 33 | 1 | 12 | 3 | | 1 | 2 | 1 | | | | | | | | 97 |
| | | 45%[a]<br>11%[b] | 34%<br>8.5% | 16.5%<br>4.1% | | | 4.1%<br>1.0% | | | | | | | | | | | |
| 2½ | | 1 | 1 | | 3 | 4 | 1 | 2 | 23 | 49 | 1 | 4 | 62 | 118 | 4 | 16 | 10 | 299 |
| | | 0.7% | | 2.3% | | | 25.1% | | | | 61.9% | | | | 10.0% | | | |
| | | 3.0%[c] | | | | | | | | | | | | | | | | |
| 3½ | | | | | | | | | | 2<br>3.3% | | | 6 | 25 | | 9 | 19 | 61 |
| | | | | | | | | | | | 50.8% | | | | 45.9% | | | |
| 4½ | | | | | | | | | | | | | | 8<br>44.4% | | 1 | 9 | 18 |
| | | | | | | | | | | | | | | | 55.6% | | | |
| 5½+ | | | | | | | | | | | | | | 2<br>18.2% | | | 9<br>81.8% | 11 |

[a] % of legal yearlings
[b] % of yearling age-class
[c] about half of these were deformed antlers owing to injury

## Diastema and Weight

Diastema, the distance on the mandible between the fourth incisor and first premolar, is considered an index of skeletal growth. It has also been considered to well represent nutritional conditions; greater diastemal length equals better nutritional conditions (Reimers 1972).

Average diastemal length by age-class for males and females (Table 11) indicated continued skeletal growth through all measured age-classes. Also, unsurprisingly, males attained greater skeletal growth in each age-class than females. An interesting phenomenon for both male and females was that slowest growth occurred between 1 year, 5 months of age and 2 years, 5 months of age.

Table 11. Diastema measurements by age class of male and female elk in the Gravelly-Snowcrest Mountains, 1984-1988.

| Age | Length of Diastema (mm) | |
|---|---|---|
| | Male | Female |
| ½ | 82.6 (72)[a] | 81.8 (136) |
| 1½ | 103.5 (131) | 99.0 (157) |
| 2½ | 104.2 (193) | 99.4 (118) |
| 3½ | 109.8 (36) | 102.6 (105) |
| 4½ | 110.5 (20) | 104.2 (135) |
| 5½ - 6½+ | 114.7 (6) | 105.6 (190) |
| 7½ - 8½ | | 109.8 (93) |
| 9½+ | | 111.2 (33) |

[a] Number in parenthesis is sample size

Diastema length of calves might be considered to be the most sensitive indicator of nutritional conditions, and these measurements did vary somewhat among years for both males and females. Variation was so great among individuals, however, that differences between years were not statistically significant. Also, correlation of diastema length with survival for that cohort was not significant ($P > 0.40$) for either males ($r = -0.35$) or females ($r = 0.43$).

No significant differences were apparent for calf diastema length among Gravelly, Gallatin, and Upper Yellowstone samples (MDFWP files). Because of the large degree of variation among individuals, large samples are necessary to detect significant differences among means. These differences were generally small. Variation among individuals may result from causes other than differences in nutrition. With the majority of most births normally spread out over about 3 weeks, and harvests occurring over a 5-week period, diastemal measurements of a "normal" years calf crop will be spread over an 8-week period of growth. This cause of variation, by itself, could lead to wide fluctuations of means that are based on relatively small samples.

Small samples of calf weights were collected, ranging from 2-9 males and 6-10 females per year. Mean field dressed weight ranged annually from 150-200 pounds for males and 147-179 pounds for females. The same interpretive problems applied to weight as discussed for diastema except that samples sizes for weights were even smaller. Weights also were not significantly ($P > 0.20$) correlated with cohort survival. The direction of the non-significant relationship was negative; lower weights were associated with higher survival.

Diastemal measurements and weights have not been as helpful as we hoped in detecting nutritional differences among individual cohorts. Collection and analysis of these measurements will continue for a while longer. Perhaps correcting for date of kill in future analysis will reduce a large portion of the variability.

## Reproduction

High pregnancy rates have been recorded for female elk in the Gravelly-Snowcrest Mountains since 1984 (Fig. 12). Over the entire period 1984-90, 36% of 59 yearling females and 96% of 214 2+ year old females were pregnant. One of 13 yearlings and all 17 females older than yearlings were pregnant during spring 1990.

Pregnancy rate of yearlings during the last 2 years has been low compared to previous years. Sample sizes were too small to detect differences in yearling pregnancy rate among individual years. However, another year with low yearling pregnancy rate would likely indicate a difference between the periods 1984-88 and 1989-91.

For females 2 years and older, a slight decline in pregnancy rate with age was indicated (Fig. 12). This slight decline is normal, and overall, pregnancy rate for this population is as high or higher than for most elk populations. No information was available for pregnancy rate prior to 1984.

An estimate of potential calf production at birth pulse rate for the 1984-89 period. On 1 June each year, 18.5 of

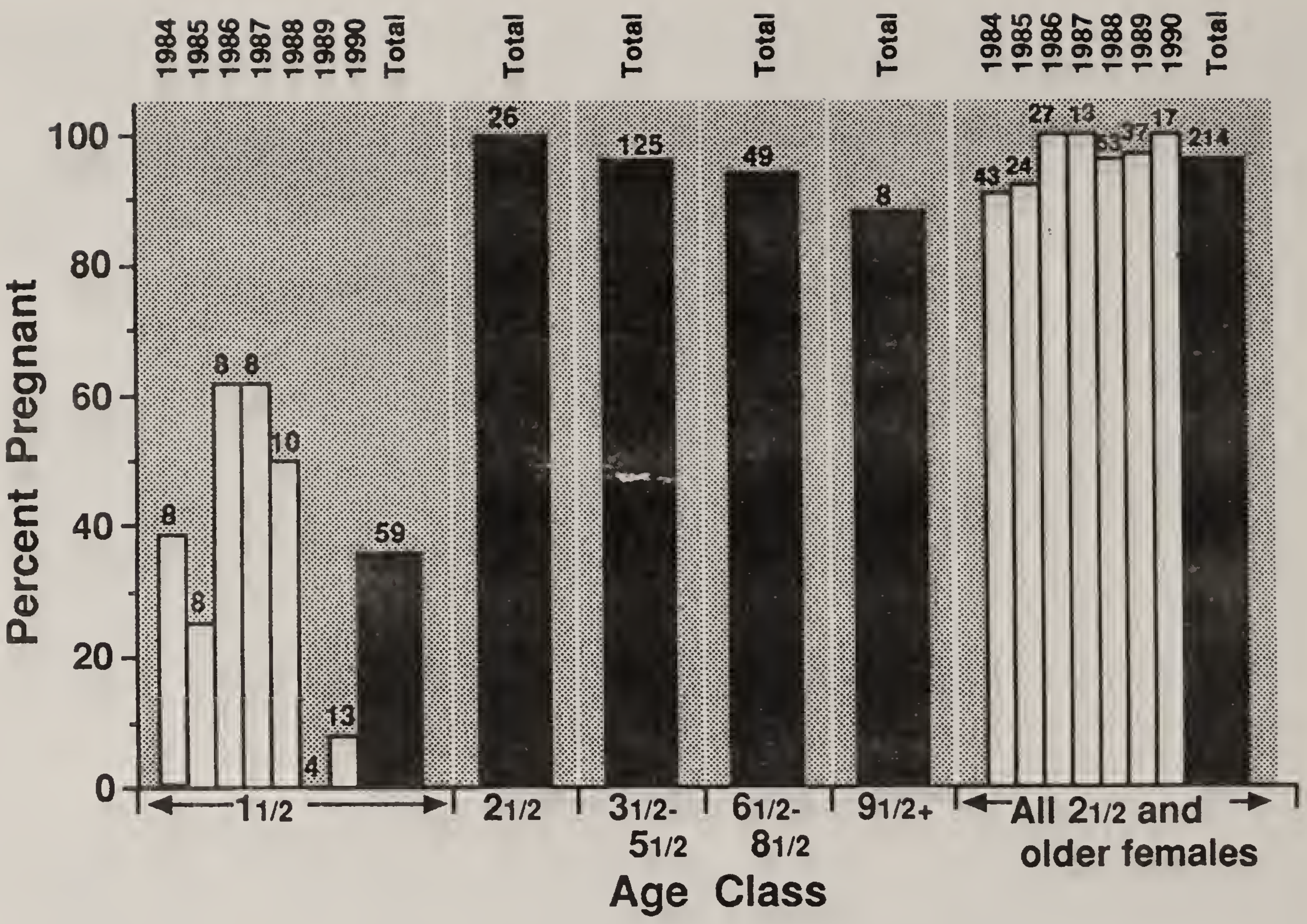


Figure 12. Pregnancy rate of captured adult female elk in the Gravelly-Snowcrest Mountains, spring 1984-90. Numbers above bars are sample sizes.

each 100 cows have just turned 1-year-old and have no newborn calves; 14.5 are 2-year-olds, 36% were pregnant, producing 5.2 newborn calves and; 67 are 3-year-olds or older, 96% were pregnant, producing 64.3 newborn calves. Thus, for each 100 cows on 1 June, an average potential of 69.5 calves are born. This potential may annually fluctuate slightly depending on pregnancy rate and age structure, but will likely remain relatively near 70 calves:100 cows. For example, if pregnancy rate of yearlings more than doubled to 75%, the potential calf:100 cow ratio at birth would only increase to 75:100.

The methods of estimating pregnancy rate continue to be relatively consistent with each other. For level of Protein B in the blood, there have been 7 (2.1%) errors or questionable results in tests on 327 elk. Six of these questionable results were animals called pregnant when other methods indicated they were open. Twelve (4.9%) errors or questionable results occurred in tests of 246 elk with the ultra sound pregnancy tester. Nine were called open when other methods indicated pregnancy, and 3 were called pregnant when other methods indicated open. Overall, Protein B may slightly overestimate pregnancy rate and ultra sound may slightly underestimate pregnancy rate.

## Mortality

### Calves

Seventy-one total newborn elk were captured and equipped with radio-transmitter collars; 20 in 1984, 8 in 1985, 20 in 1986, 9 in 1987, and 14 in 1988. Eleven of these calves died within 2 weeks of their capture. Nine died of "starvation" and 2 of apparent black bear predation. Eight of the 9 starvation victims were apparently abandoned by their mothers; the other was attended by its mother. We do not know whether the observed abandonment was natural or induced by capture and marking. The total level of mortality observed including the abandonment, however, was not excessive when compared to average survival for the population as determined from calf:100 cow ratios.

The 11 deaths represented 15.5% mortality for 71 calves, assuming that all the others survived summer. This is not certain because the transmitters of most either quit or were shed before a full year, including several during summer. The 84.5% survival rate times 69.5 potential calves:100 cows equals 58.7 calves:100 cows by mid-summer, which is within the range of 50-60:100 observed during late July surveys. All this collectively could indicate that the observed abandonment was natural. It also substantiates the observed pregnancy rates, age structure, and summer classifications.

Transmitter failure and collar loss considerably reduced sample size during the remainder of the year. We do know that 4 calves (10.3%) of 39 with transmitters that functioned throughout the hunting season were shot. Observed calf:100 cow ratios ranged from 35-59:100 during March in 1984-89 and were generally lower or the same as in summer classifications. Because harvest rates for adult females were higher than for calves, however, winter calf:100 cow ratios should be increased by the harvests. This indicated that some calf mortality continued after mid-summer. Except for 1 female calf marked at 9 months of age and found dead in a fence 1 month later, we have not detected this additional mortality among marked animals.

### Adult females

Annual mortality rates were calculated for adult females from a sample that contained only females with functioning radio-transmitter collars (Table 12). During the first 2 years, the sample contained only animals marked on the Wall Creek Game Range. The smaller samples from this more lightly

Table 12. Mortality rates of adult female elk ($\geq$ 1 year) based on a sample with functioning radio-transmitter collars.

| Time | N | Total Deaths | Shot | Crippling Loss | Shot - Not Reported | Natural[a] | Unknown | Total Hunting Related |
|---|---|---|---|---|---|---|---|---|
| 1 June 1984 through 31 May 1985 | 26 | 2 (7.7)[b] | 1 | 0 | 0 | 1 | 0 | 1 (3.9)[b] |
| 1 June 1985 through 31 May 1986 | 52 | 4 (7.7) | 2 | 1 | 1 | 0 | 0 | 4 (7.7) |
| 1 June 1986 through 31 May 1987 | 59 | 3 (5.1) | 2 | 0 | 0 | 1 | 0 | 2 (3.4) |
| 1 June 1987 through 31 May 1988 | 64 | 11 (17.2) | 11 | 0 | 0 | 0 | 0 | 11 (17.2) |
| 1 June 1988 through 31 May 1989 | 64 | 11 (17.2) | 10[c] | 0 | 1 | 0 | 0 | 11 (17.2) |
| 1 June 1989 through 31 May 1990 | 79 | 13 (16.5) | 9 | 1 | 1 | 1 | 1 | 11 (13.9) |
| Total | | 44 | 35 (79.6) | 2 (4.6) | 3 (6.8) | 3 (6.8) | 1 (2.3) | 40 (90.9) |

[a] Natural loss includes old age, malnutrition, disease, calving problems, predation, etc.
[b] Number (%)
[c] Includes one archery-kill

hunted and rugged area did not represent mortality rates for the entire population. During 1986-87, elk were marked on the Blacktail Game Range as well but mortality rate remained low. During the last 3 years, the sample was more balanced between the WCGR and BTGR as well as other areas and annual mortality rates (14-17%) probably more nearly represented actual rates experienced by the population. Mortality rates could be slightly higher than those reported if working transmitter collars were removed from the area after harvest and not reported.

Ninety-one percent of the annual mortality for adult cows was hunting related including a known 4.6% crippling loss (Table 12). Thus far, known annual natural mortality has averaged only a little over 1%. Causes of mortality were very similar from a sample that also included cows with only neckbands or non-functioning transmitters (Table 13).

Eleven (11.8%) of 93 known hunting-related mortalities of marked adult cows were shot in Idaho.

Table 13. Causes of mortality for radio-transmitter collared and neckbanded adult elk (≥ 1 year).

| Causes of Mortality | Females | Males | | |
|---|---|---|---|---|
| | | 1-2 Years | ≥ 2 Years | Total |
| Rifle hunting | 82 (82.0)[a] | 7 (70) | 46 (92) | 53 (88.3) |
| Archery hunting | 2 (2.0) | | 1 (2) | 1 (1.7) |
| Crippling loss - abandonment (rifle)[b] | 6 (6.0) | | 2 (4) | 2 (3.3) |
| Crippling loss - abandonment (archery)[b] | | | 1 (2) | 1 (1.7) |
| Shot and not reported or returned[b] | 3 (3.0) | | | |
| Illegal kill (spikes)[b] | | 2 (20) | | 2 (3.3) |
| Natural deaths[b] | 5 (5.0) | 1 (10) | | 1 (1.7) |
| Unknown | 2 (2.0) | | | |
| TOTAL | 100 | 10 | 50 | 60 |
| Total Hunting Related | 93 (93.0) | 9 (90) | 50 (100) | 59 (98.3) |

[a] Number (%)

[b] Because animals with non-functioning radio-transmitter collars and neckbands are included, the number and % in these categories is an absolute minimum.

## Adult Males

Ninety-eight percent of known causes of death for marked males was hunting related (Table 13). Only one natural death was known, an apparent predation loss of a yearling male. Two (20%) of a small sample of 10 mortalities of yearling males were illegally killed spike (1x1) males.

Samples for males were too small to calculate annual mortality rates, so average mortality by age class was calculated as a composite for all years. For a sample in which the transmitter collar functioned throughout full year increments, 3 (16.7%) of 18 yearling males died and 24 (85.7%) of 28 males 2+ years old died.

For a larger sample of all males known to enter an age class, 4 (12.5%) of 32 yearling males were known to have died and 18 (56.3%) were known to have survived. Inclusion of the males of undetermined fate (31.2%) as mortalities raises yearling male mortality rate as high as 43.7%. Although some of these could have survived to 2 years or more, been harvested and not reported, that number is likely small. The fact that 31.2% of yearling males disappeared and were never seen or reported again in this heavily hunted area is suggestive of illegal mortality. To date, the best we can estimate mortality of yearling males based on marked animals is to place it in a range between 12.5 and 43.7%. Twenty to 25% of yearling males should have been legally branched, and some additional harvest of all yearlings does take place in Idaho.

The larger sample of males known to enter an age class alive indicated that 28 (70.0%) of 40 males 2+ years old died and 9 (22.5%) lived. This sample estimated a range of 70-77.5% annual mortality for 2+ year old males. The combined range estimated by both methods for annual mortality of 2+ year old males was 70-86%.

Of 59 known hunting-related mortalities of marked adult bull elk, 4 (6.8%) were shot in Idaho.

## Harvest Surveys and Check Stations

Based on the statewide hunter questionnaire (Fig. 13), total bull harvest in Gravelly-Snowcrest hunting districts increased steadily from 1972 through 1979. Most of that increase was contributed by yearling bulls. Total bull harvest declined in 1980 and continued to decline through 1981 when branch-antlered bull regulations were implemented in HD 324. Total bull harvest and especially harvest of 2+ year old bulls increased in 1982. This indicated that many spike-antlered yearlings not harvested in 1981 because of branch-

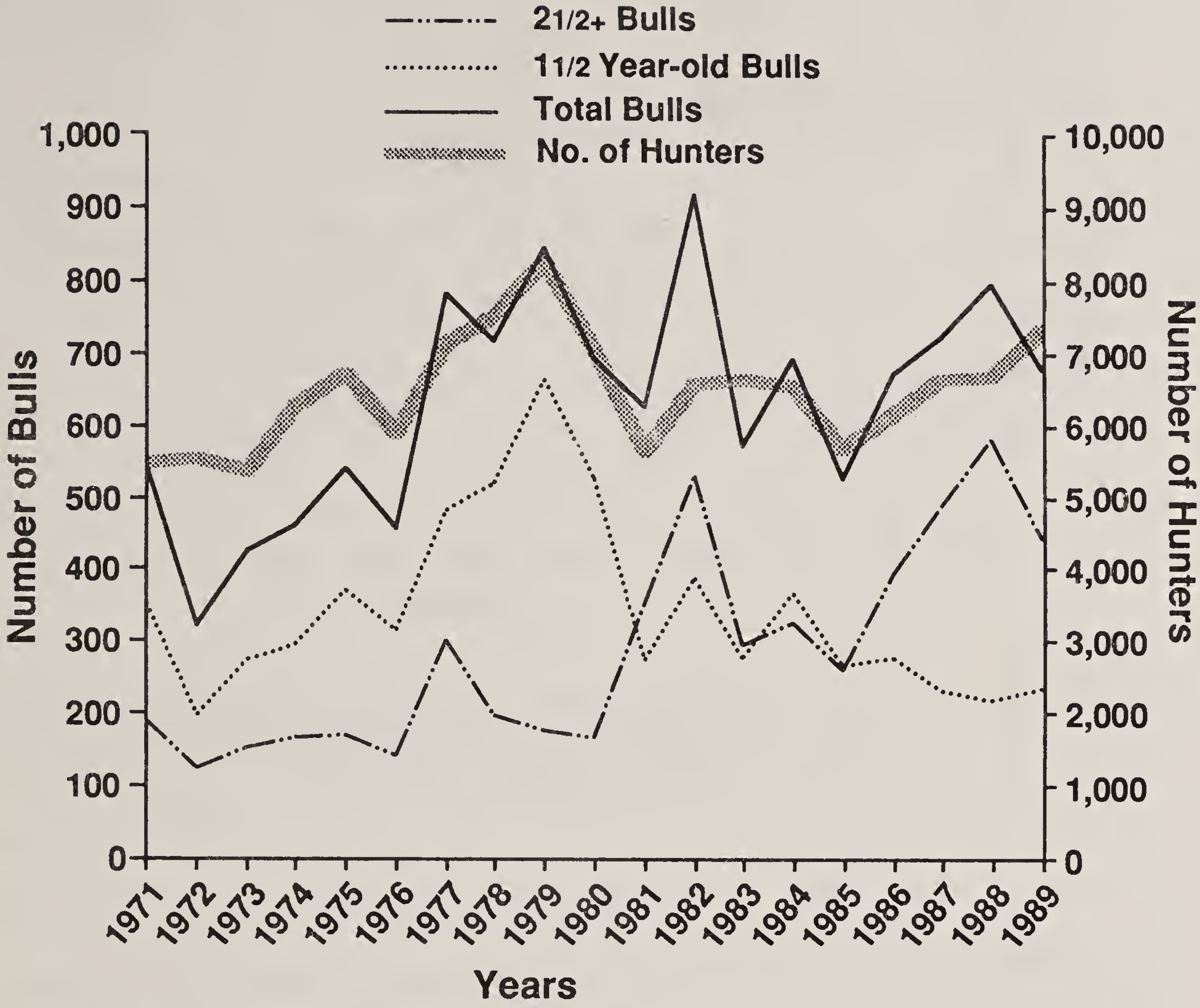


Figure 13. Number of hunters and harvest of total bulls, yearling bulls, and 2+ year old bulls in Gravelly-Snowcrest hunting districts as estimated by the statewide hunter questionnaire, 1971-89.

antlered regulations, carried over and were harvested as 2 year olds in 1982 (Fig. 13). Total bull harvest has remained below 1982 levels in all subsequent years and increases in harvests of 2+ year old bulls has not compensated for decreased reported harvest of yearlings.

When harvest was partitioned by hunting district (Figs. 14 and 15), the same trends were apparent. Total bull harvest in HD 324 (Fig. 12) declined during 1981, the first year of BAB regulations, recovered during the second year, and has fluctuated at lower than pre-1980 levels since. Total bull harvest in HDs 323, 326 and 330 (Fig. 14) and HDs 325 and 327 (Fig. 15), which remained open to any antlered bull, increased

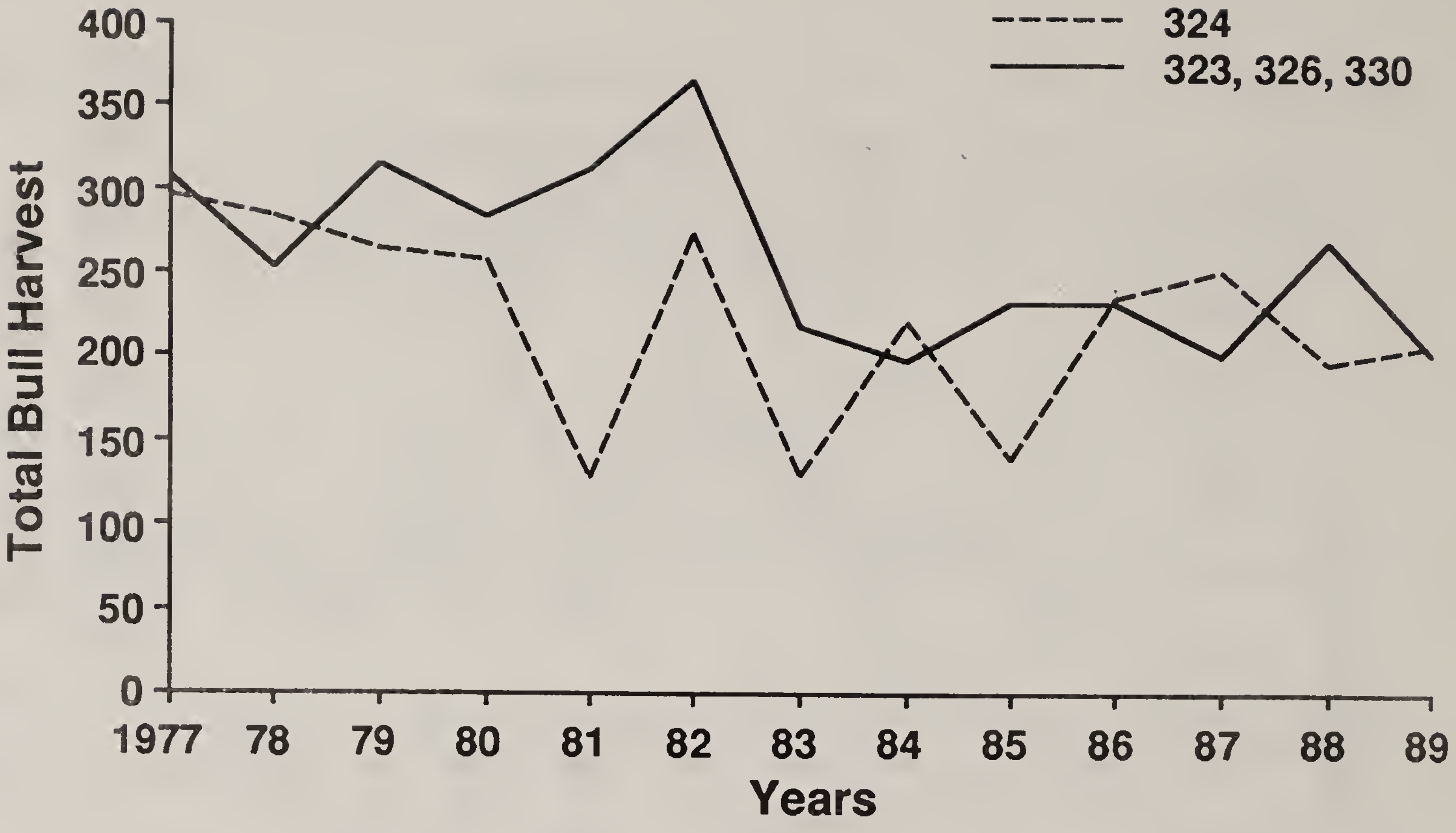


Figure 14. Total bull harvest in HD 324 and in HDs 323, 326, and 330 as estimated by the statewide hunter questionnaire, 1977-89.

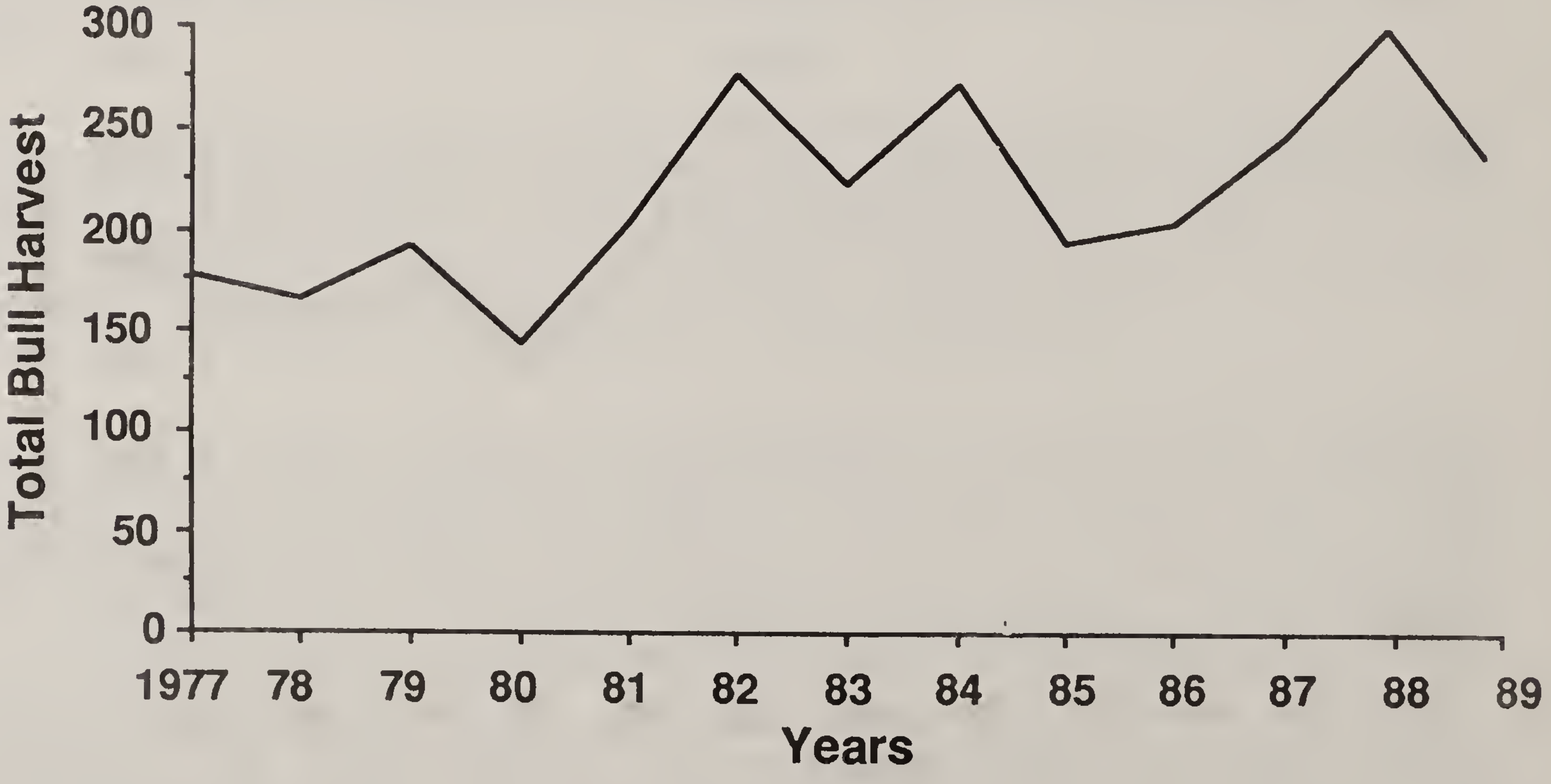


Figure 15. Total bull harvest in HDs 325 and 327 as estimated by the statewide hunter questionnaire, 1977-89.

through 1982. Harvest declined in HDs 323, 326, and 330 during the first year of BAB regulations (1983) and has remained lower than peak levels since. Total bull harvest did not decline below pre-1980 levels in HDs 325 and 327. Rather, these units which did not change to BAB regulations until 1987, increased in harvest through 1982 and have roughly stabilized around 1982 levels.

The apparent lack of carry-over of many "protected" spike-antlered yearlings after 1982 becomes even more obvious when concurrent population increases are considered (Fig. 5). Total bull harvest averaged 759 animals during 1977-1980, immediately prior to BAB regulations. During the most recent 3 years, 1987-89, total bull harvest has averaged 732 animals. Thus, total legal bull harvest reported has declined or remained roughly the same despite a minimum 50% increase in total population size over the same period (Fig. 5).

A major portion of the decline and stabilization of bull harvest during the mid 1980s can be explained by poor calf survival. Although the number of cows producing calves increased, calf survival declined at a faster rate, resulting in fewer bulls recruited into the population. The relative impact of female numbers and calf survival rates on numbers of bulls recruited (Table 14) indicated that about a 20% decline in the number of bulls available to be harvested was to be expected because of poor calf survival during the mid-1980s.

Table 14. Impact of calf survival rate and adult female numbers on recruitment of yearling bulls.

| Time | Relative Number of Adult Females | Average Calf Survival Rate | Number of Surviving Calves | Number of Yearling Bulls in Autumn |
|---|---|---|---|---|
| 1977-80 | 1000 x | 0.55 = | 550 = | 275 |
| 1984-85 | 1305 x | 0.35 = | 456 = | 228 |
| 1987-89 | 1520 x | 0.45 = | 684 = | 342 |

Both calf survival and the female population have increased recently (Figs. 5, 6, and 7). The results of this (Table 14) indicated that bulls available for harvest should have increased over all previous levels, including the record levels of 1977-80. Total bull harvest has increased since 1985 (Fig. 11) but has remained below 1977-80 levels. Increased numbers of yearling bulls recruited are not surviving to 2-years-of-age. A combination of evidence indicated that illegal mortality of spikes has recently increased resulting in reduced numbers of available 2 year old bulls and lower than expected levels of reported legal harvest.

Another method of calculating mortality of yearling males (Table 15) indicated similar conclusions to those just discussed. The results of this method (Table 16) indicated relatively few "missing" spike bulls after the first BAB season in 1981. However, about 55% of the spike bulls expected to be observed on the winter range after the 1982 hunting season were not observed (Table 16). Actually, because most hunting units in the Gravelly-Snowcrest Mountains were legal for any antlered bull until 1983, this method of calculating mortality should result in many "missing" bulls through spring 1983. Thus, through spring 1983 most of the "missing" bulls were legally harvested.

Table 15. Example of a method of calculating mortality rate of yearling males based on classifications and harvest data.

---

Spring 1987

= 56 calves/100 cows survive
= 28 male calves and 28 female calves
= 28 yearling males, Oct. 20, 1987

28 yearling females + 100 cows = 128 cows
October 20, 1987

28 yearling bulls/128 cows
20-25% of yearling bulls legally branch--
if hunters harvest every one of them, and
we use 25%, there should be 21 yearling males
left (28 - 7 shot) after the season

cow harvest has been 14-17% of preseason cow
populations
21 yearling bulls/128-18 (14%) = 110
  21/110 = 19 yearling bulls/100 cows
21 yearling bulls/128-22 (17%) = 106
  21/106 = 20 yearling bulls/100 cows

Spring 1988

Thus, we should have seen 19-20 yearling bulls (spikes) minimum/100 cows after the hunting season. We did see 13 yearling bulls/100 cows.

6/19 = 32% of yearling bulls are missing
7/20 = 35% of yearling bulls are missing

---

Table 16. Expected and observed yearling bull:100 cow ratios.

| Autumn-Spring | Expected[a] Yearling Bulls:100 cows | Observed[b] Yearling Bulls:100 cows | % Yearling Bulls[c] Missing |
|---|---|---|---|
| 1981-1982 | 11.1-11.6 | 10.3 | 7-11 |
| 1982-1983 | 14.7-15.2 | 6.7 | 54-56 |
| 1983-1984 | 13.2-13.6 | 13.6 | 0 |
| 1984-1985 | 14.0-14.4 | 12.2 | 13-15 |
| 1985-1986 | 12.6-13.0 | 14.3 | 0 |
| 1986-1987 | 15.1-15.7 | 13.0 | 14-17 |
| 1987-1988 | 19.1-19.8 | 13.3 | 30-33 |
| 1988-1989 | 17.4-18.1 | 9.5 | 46-47 |
| 1989-1990 | 16.2-16.8 | 14.3 | 12-15 |

[a] Expected calculated as illustrated in Table 14
[b] Observed on winter range
[c] Calculated as illustrated in Table 14

From spring 1984 through spring 1987 (hunting seasons of 1983-86), the number of spike bulls observed on the winter range was about as expected, although in spring 1985 and 1987 about 15% were "missing". This information verified the previous conclusion that illegal mortality of spike bulls was relatively low during autumn 1981 and 1983-86 and that low calf survival accounted for most of the low bull harvest. During spring 1988 and 1989, 30-50% fewer spike bulls were observed on the winter range than expected based on calf survival and legal hunter harvest (Table 16). Illegal mortality may have been substantial during autumn 1987 and 1988.

The numbers and percentages discussed in this section are not meant to be precise estimates. Rather, they indicate the general direction of change in population numbers and mortality rates. Thus, the 30-33% "missing" yearling bulls estimated for spring 1988 could have been 25% or 40%. The methods used are good enough, however, to be certain that substantially more yearling bulls were "missing" after autumn 1987 than after autumn 1986. The expected number of yearling bulls on the winter range will vary with the accuracy of classifications, the sex ratio of recruited calves, and branching rate of yearling bulls. Errors in collection of this data or assumptions about them will result in errors in the estimate of percentage of "missing" bulls. For example, if branching rate is less than 25%, fewer than actual numbers of bulls will be estimated to be "missing". Overall, this method appeared to underestimate the number and percentage of "missing" bulls. At least some illegal mortality of spikes was known to occur every year despite estimates by this method of no "missing" bulls in some years.

Reported antlerless harvest from the statewide hunter questionnaire (Table 17) was closely correlated (r = 0.97) with number of permits issued. Similarly, although success rate fluctuated somewhat due to weather conditions and other factors, it usually remained very close to the mean of 48%. Taken together, these results indicated that antlerless permits have not been at levels that would reduce the population substantially enough to reduce hunter success.

Table 17. Antlerless harvest in HDs 322, 323, 324, 325, 326, 327, and 330 based on the statewide hunter questionnaire.

| Year | No. of Permits | Cows Harvested | Calves Harvested | Total Harvested | Percent Success |
|---|---|---|---|---|---|
| 1967 | 125 | 156 | 14 | 170 | -- |
| 1968 | 470 | 290 | 48 | 338 | 72 |
| 1969 | 700 | 336 | 71 | 407 | 58 |
| 1970 | 735 | 280 | 33 | 313 | 43 |
| 1971 | 674 | 192 | 27 | 219 | 32 |
| 1972 | 672 | 189 | 60 | 249 | 37 |
| 1973 | 475 | 171 | 34 | 205 | 43 |
| 1974 | 300 | 92 | 17 | 109 | 36 |
| 1975 | 300 | 134 | 18 | 152 | 51 |
| 1976 | 350 | 138 | 25 | 163 | 47 |
| 1977 | 350 | 184 | 28 | 212 | 61 |
| 1978 | 716 | 302 | 39 | 341 | 48 |
| 1979 | 576 | 243 | 43 | 286 | 50 |
| 1980 | 425 | 195 | 18 | 213 | 50 |
| 1981 | 325 | 149 | 20 | 169 | 52 |
| 1982 | 725 | 396 | 29 | 425 | 59 |
| 1983 | 1,275 | 596 | 74 | 670 | 53 |
| 1984 | 1,775 | 719 | 96 | 815 | 46 |
| 1985 | 1,950 | 709 | 122 | 831 | 43 |
| 1986 | 1,500 | 500 | 89 | 589 | 39 |
| 1987 | 1,500 | 606 | 67 | 673 | 45 |
| 1988 | 1,750 | 771 | 98 | 869 | 50 |
| 1989 | 1,950 | 721 | 123 | 844 | 43 |

Although total antlerless harvest may be relatively accurate as reported (Table 17), other information (Table 8) indicated that calves are underreported and cows and probably yearling bulls are overreported. Consistent adjustment factors (if they exist) have not yet been determined.

Results from 3 check stations operated consistently since 1986 (Table 18) indicated that harvest of both yearling and 2+ year old bulls has been relatively stable. A gradual increasing trend in harvest of 2+ year old bulls occurred as HDs 325 and 327 were changed to BAB management. Harvests at individual check stations were more variable among years, perhaps indicating variable weather and elk distribution patterns.

Harvest data were collected in the upper Ruby prior to this study, especially in conjunction with the road closure study in 1970-74. These data are included with those collected since 1984 (Table 19) to indicate possible changes resulting from branch-antlered bull management. During the 1970s, under any antlered bull management, 82% of the checked harvest of bulls was yearlings. Since 1984, 23% of the checked harvest of bulls has been yearlings. Total checked bull kill was similar between the 2 periods despite an increase in the elk population. Antlerless harvest has increased, relating to an increased population and increased numbers of permits. The number of hunters checked opening day as a percentage of those checked season-long has declined from 31% during the 1970s to 23% after 1984. This may at least partially be related to partitioning of antlerless permits into different time periods in recent years.

The statewide hunter questionnaire indicated that the percentage of the total bull harvest that occurred during the first 2 weeks of the season increased from about 65% during 1971-75 to above 75% during 1976-78 (Fig. 16). This percentage then declined to about 60% in 1982 and has since remained at about that level. The percentage of bulls that were shot during the first week of the season declined from around 55% during the late 1970s and early 1980s to about 40% in 1988 and 1989. Similar data from check stations (Fig. 17) also portrayed a general decline in the percent of elk harvested during the first 2 weekends of the season during 1984-89. The general lengthening of the time distribution of bull kill over the years may be related to a combination of 3 factors: road closures, time partitioning of antlerless permits, and the branch-antlered bull regulation. Road closures and the branch-antlered bull regulation may allow greater escapement. Time partitioning

Table 18. Season-long results from hunter check stations operated in the Gravelly-Snowcrest Mountains during 1984-1989.

| Check Station[a] | Year | No. Hunters | Elk |  |  |  | Mule Deer |  |  | White-tailed Deer |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Males |  | Females | Calves | Males | Females | Fawns | Males | Females | Fawns |
|  |  |  | Yrlng. | 2+ |  |  |  |  |  |  |  |  |
| All | 1984 | 3,425 | 16 | 40 | 97 | 25 | 154 | 106 | 51 | 26 | 6 | 3 |
|  | 1985 | 3,124 | 12 | 72 | 110 | 31 | 214 | 121 | 29 | 23 | 5 | 3 |
|  | 1986 | 6,231 | 33 | 89 | 99 | 30 | 309 | 155 | 46 | 63 | 19 | 22 |
|  | 1987 | 5,075 | 31 | 93 | 135 | 33 | 376 | 135 | 32 | 49 | 14 | 15 |
|  | 1988 | 4,944 | 36 | 95 | 178 | 39 | 450 | 112 | 28 | 46 | 19 | 18 |
|  | 1989 | 5,001 | 26 | 97 | 136 | 58 | 328 | 98 | 20 | 50 | 8 | 13 |
| Ruby | 1984 | 1,698 | 11 | 23 | 57 | 11 | 127 | 100 | 43 | 20 | 6 | 3 |
|  | 1985 | 1,623 | 10 | 46 | 82 | 27 | 161 | 105 | 27 | 19 | 5 | 3 |
|  | 1986 | 2,172 | 11 | 42 | 47 | 14 | 146 | 93 | 30 | 33 | 9 | 18 |
|  | 1987 | 2,135 | 14 | 36 | 69 | 18 | 175 | 83 | 18 | 26 | 4 | 7 |
|  | 1988 | 2,096 | 14 | 39 | 62 | 19 | 204 | 62 | 15 | 17 | 6 | 9 |
|  | 1989 | 1,832 | 4 | 28 | 55 | 27 | 147 | 43 | 9 | 19 | 1 | 3 |
| Blacktail Road | 1986 | 1,882 | 11 | 20 | 28 | 9 | 102 | 39 | 5 | 24 | 10 | 4 |
|  | 1987 | 1,930 | 11 | 29 | 38 | 7 | 135 | 38 | 10 | 18 | 10 | 7 |
|  | 1988 | 1,831 | 11 | 25 | 53 | 3 | 136 | 38 | 9 | 21 | 11 | 7 |
|  | 1989 | 2,256 | 14 | 40 | 48 | 23 | 137 | 42 | 11 | 26 | 4 | 9 |
| Ennis | 1986 | 2,177 | 11 | 27 | 24 | 7 | 61 | 23 | 11 | 6 | 0 | 0 |
|  | 1987 | 1,010 | 6 | 28 | 28 | 8 | 66 | 14 | 4 | 5 | 0 | 1 |
|  | 1988 | 1,017 | 11 | 31 | 63 | 17 | 110 | 12 | 4 | 8 | 2 | 2 |
|  | 1989 | 913 | 8 | 29 | 33 | 8 | 53 | 13 | 0 | 5 | 3 | 1 |

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[a] The Upper Ruby Creek Check Station was the only one operated each year 1984-1989. In 1984 and 1985, 2-3 other stations were manned on the east side of the Gravellys. In 1986, those were combined into one station at Ennis and a new station was opened on the Blacktail Road south of Dillon.

Table 19. Hunter and harvest statistics for the Ruby check station.

| Year | Season-Long | | | | | | First Two Days | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Hunters | Yearling Males | 2+ Males | Total Males | Females | Calves | Number of Hunters | Yearling Males | 2+ Males | Total Male Kill as % of Season Kill |
| 1968 | -- | -- | -- | -- | -- | -- | -- | 25 | 7 | -- |
| 1969 | -- | -- | -- | -- | -- | -- | -- | 13 | 5 | -- |
| 1970 | 2,870[a] | 42 | 8 (16)[b] | 50 | 49 | 5 | 665[c] | 10[c] | 5[c] | -- |
| 1971 | 2,371[a] | 33 | 6 (15) | 39 | 28 | 9 | 777 (33)[d] | 16 | 5 | 54 |
| 1972 | 2,415 | 24 | 5 (17) | 29 | 28 | 12 | 754 (31) | 14 | 2 | 55 |
| 1973 | 2,543 | 49 | 11 (18) | 60 | 17 | 4 | 874 (34) | 29 | 8 | 62 |
| 1974 | 2,250 | 31 | 9 (23) | 40 | 11 | 2 | 584 (26) | 6 | 4 | 25 |
| 1984 | 1,698 | 11 | 23 (68) | 34 | 57 | 11 | 403 (24) | 8 | 13 | 62 |
| 1985 | 1,623 | 10 | 46 (82) | 56 | 82 | 27 | 347 (21) | 15 | 15 | 54 |
| 1986 | 2,172 | 11 | 42 (79) | 53 | 47 | 14 | 538 (25) | 4 | 22 | 49 |
| 1987 | 2,135 | 14 | 36 (72) | 50 | 69 | 18 | 512 (24) | 9 | 11 | 40 |
| 1988 | 2,096 | 14 | 39 (74) | 53 | 62 | 19 | 422 (20) | 9 | 17 | 49 |
| 1989 | 1,832 | 4 | 28 (88) | 32 | 55 | 27 | 482 (26) | 2 | 10 | 38 |

[a] adjusted to equalized season length
[b] number (% of all bulls)
[c] data for 1 day only
[d] number of hunters (% of season-long total)

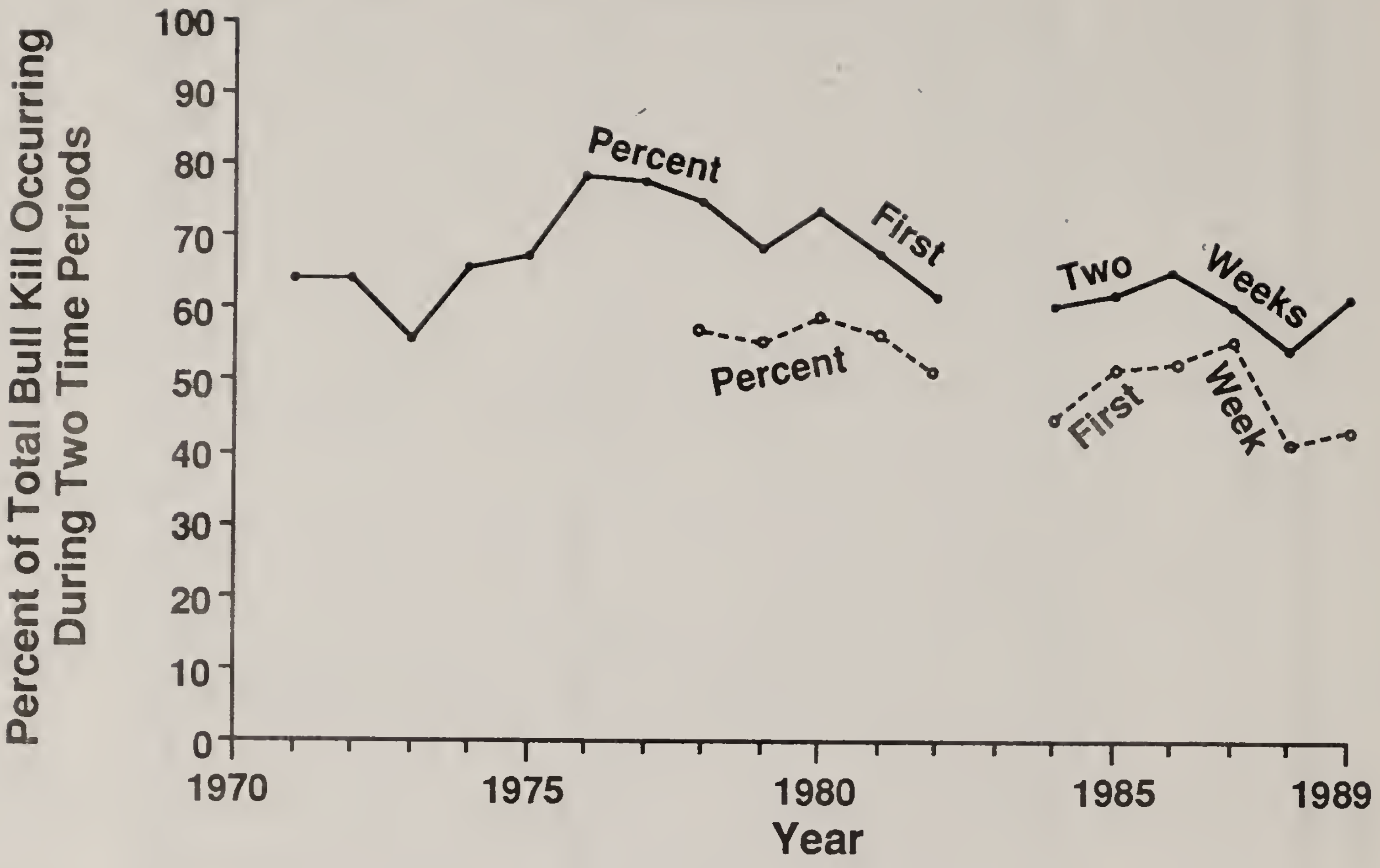

Figure 16. Percent of the total bull kill that occurred during the first two weeks and the first week of the hunting season as estimated by the statewide hunter questionnaire, 1971-89.

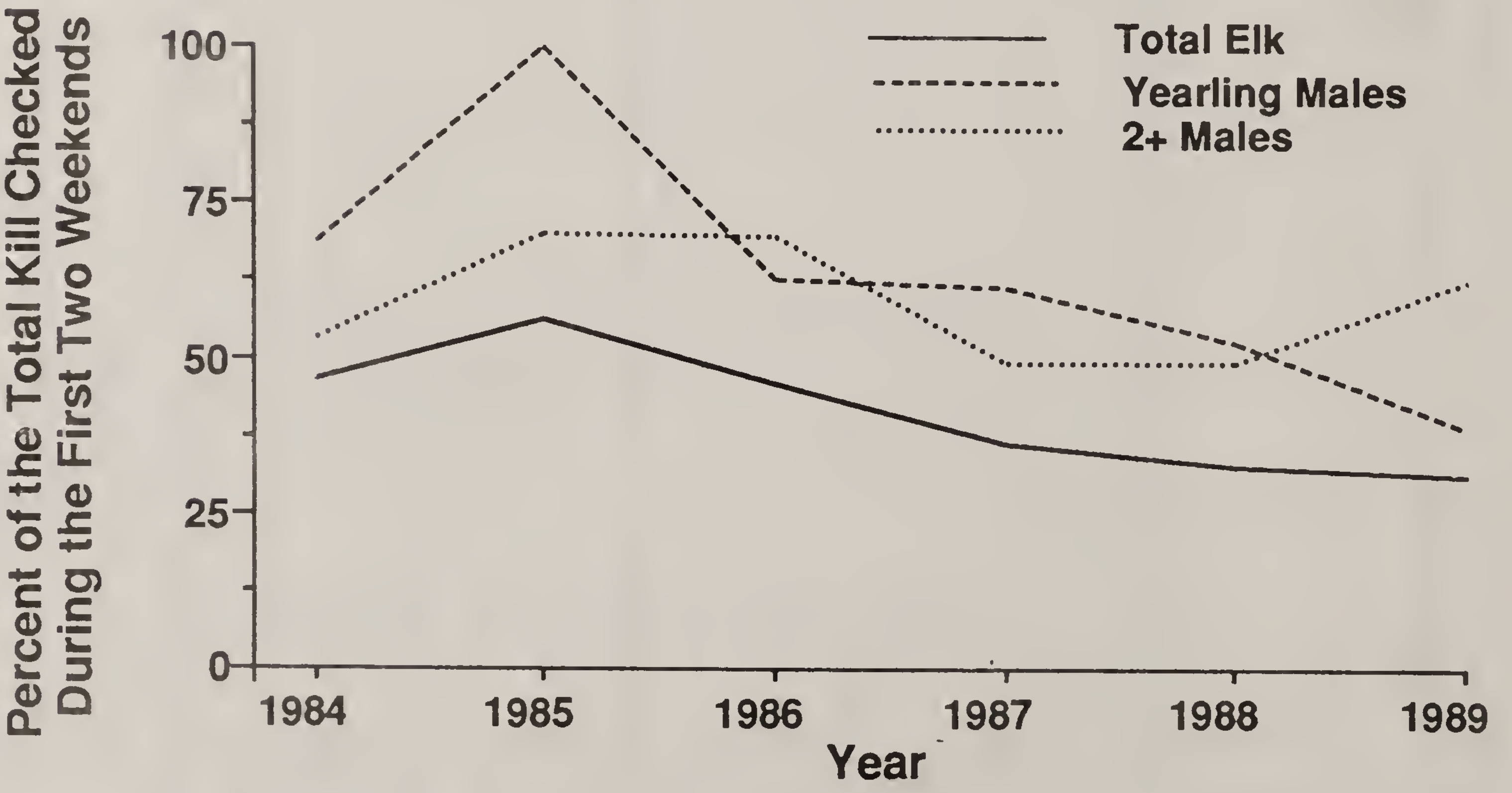

Figure 17. Percent of the total elk kill, yearling male kill, and 2+ year old male kill recorded in the first two weekends at check stations, 1984-89.

of antlerless permits may shift some hunting pressure away from the first week. It is important to note that in this relatively open habitat, the effect of even all 3 factors operating together has not resulted in major changes in the time distribution of bull kill.

## Disease

Blood samples from most elk handled to date have been tested for antibodies against bluetongue (N = 542), brucellosis (N = 541), leptospirosis (N = 540), and anaplasmosis (N = 539). All tests for bluetongue have been negative.

None of the 114 elk tested in 1990 were positive for brucellosis. The 3 (0.6%) positive reactors in 1988 (Hamlin and Ross 1990) remain the sole positives among 541 elk. It is perhaps significant that the only positive reactors have been from Wall Creek, the herd most closely associated with Yellowstone National Park.

Positive leptospirosis reactions have occurred in 19.1% (103 of 540) of the elk tested. Serovar bratislava was first tested for in 1990. Inclusion of this serovar resulted in an overall positive rate of 20.9% (113 of 540). If previous years' data were adjusted to reflect the rate that the sample of 1990 was positive for bratislava with no other reactive serovars in that animal, the overall positive rate for leptospirosis might be about 25% (136 of 540). The number of positive reactions by serovar thus far is: autumnalis - 39; grippotyphosa - 37; icterohaemorrhagiae - 30; bratislava - 21; tarassovia - 4; and hardjo -1. Results from 1990 suggest that had tests been conducted for bratislava during all years, it would be the most common serovar reactor.

All elk tested in 1990 were negative for anaplasmosis. Six positive (1.1%) and 3 suspect reactions to this disease were recorded in prior years. The complement - fixation test used for diagnosis of this disease often gives false positive test results in wildlife species (see discussion in Hamlin and Ross 1990).

There was no indication that any of these diseases has affected elk reproduction. Positive reactions may just indicate that elk have been exposed to the disease at some time rather than that they have had clinical or active cases of the disease.

Tests were conducted for three additional diseases during 1990. Positive reactions for infectious bovine rhinotracheitis were found in 10 (9.0%) of 111 elk.

Positive reactions for bovine viral diarrhea were found in 83 (79.1%) of 105 elk. Positive reactions for parainfluenza 3 were found in 21 (27.3%) of 77 elk. Little is known about these diseases in relation to wildlife. There is no evidence in the elk population to support large impacts by active infections. Perhaps all these results mean is that elk have been exposed to domestic livestock and their diseases.

## Distribution and Movements

### Madison-Wall Creek Game Range Elk

Yearlong distribution of 154 adult female elk marked on the Madison-Wall Creek Game Range (Fig. 18) indicated a total female herd range of 2593 $mi^2$ (6716 $km^2$). These 2,333 relocations were made between March 1984 and 30 June, 1990. Two females that made long-range dispersals into Idaho are not included. The number of females included in this plot is lower than that previously presented (Hamlin and Ross 1990) because elk marked on the adjacent Cherry-Morgan winter range were deleted and are presented separately in this report.

Most yearlong movements were confined to HD 323 (Fig. 18). Other concentrations of summer-autumn distribution included the east side of the upper Ruby River, the West Fork of the Madison River, the Horn Mountains, Cliff Lake Bench, the Centennial Mountains near Sawtell Peak, Henrys Lake, and Island Park Idaho, the Madison Plateau in and near Yellowstone National Park, and the mountains south of Earthquake Lake.

These data also indicated some interchange with other winter range areas, especially the Cherry-Morgan wintering area and the Blacktail-Robb-Ledford wintering area (Fig. 18). Preliminary analysis of females switching winter ranges yielded no consistent pattern. Of 18 females known to switch winter ranges, most were older than yearlings when the movement occurred. Further analysis of dispersal movements will occur in future reports.

Yearlong distribution of 424 relocations of 59 adult males marked on the WCGR (Fig. 19) encompassed a herd range of 2480 $mi^2$ (6425 $km^2$). Similar to females, the majority of WCGR males were within HD 323. Proportional to numbers marked and relocations made, however, males were distributed more widely than females. One male that dispersed to the Tobacco Root Mountains was not included in analysis.

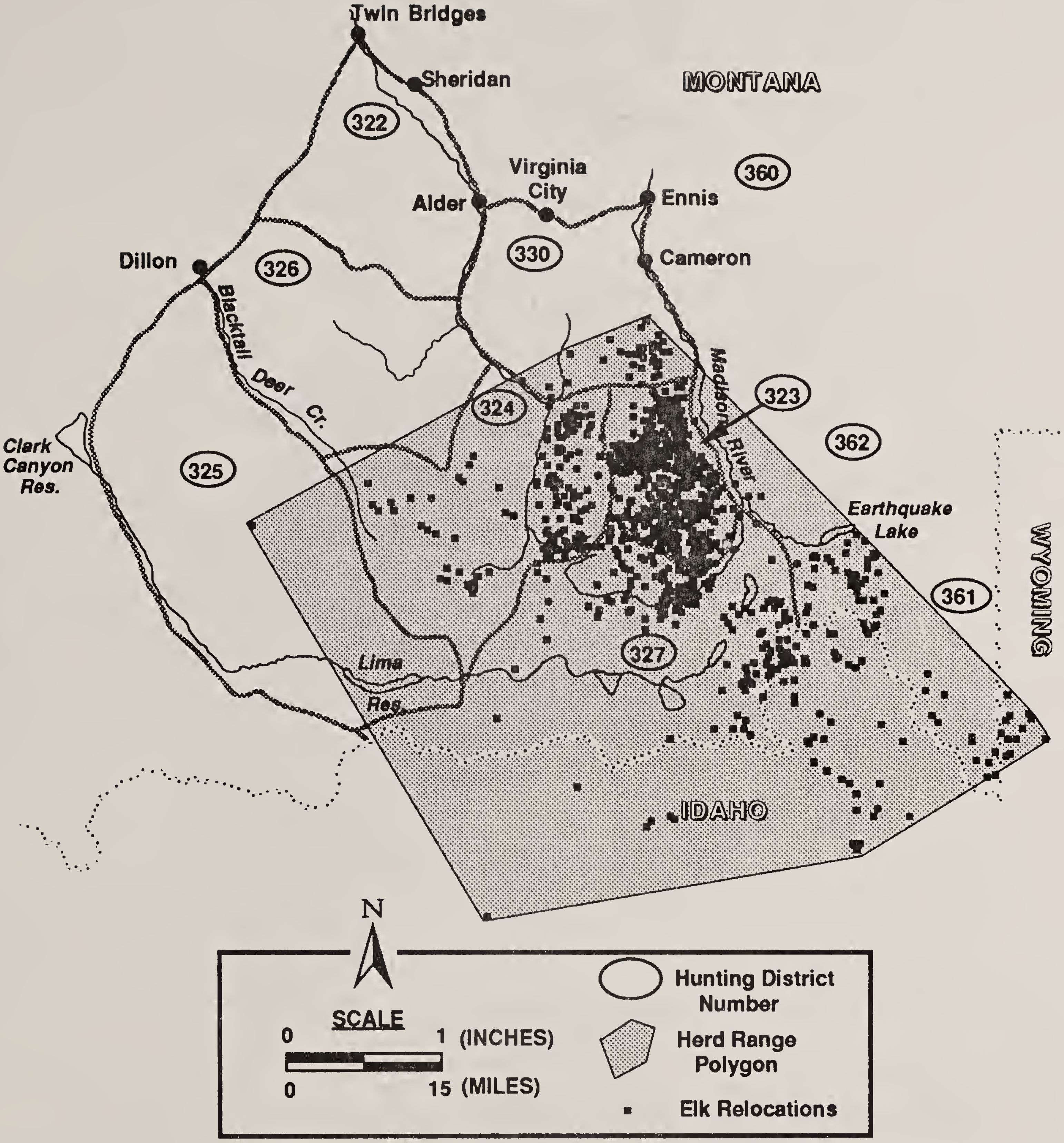

Figure 18. Yearlong distribution of 154 adult female elk marked on the Madison-Wall Creek Game Range based on 2,333 relocations made from March 1984 through 30 June, 1990.

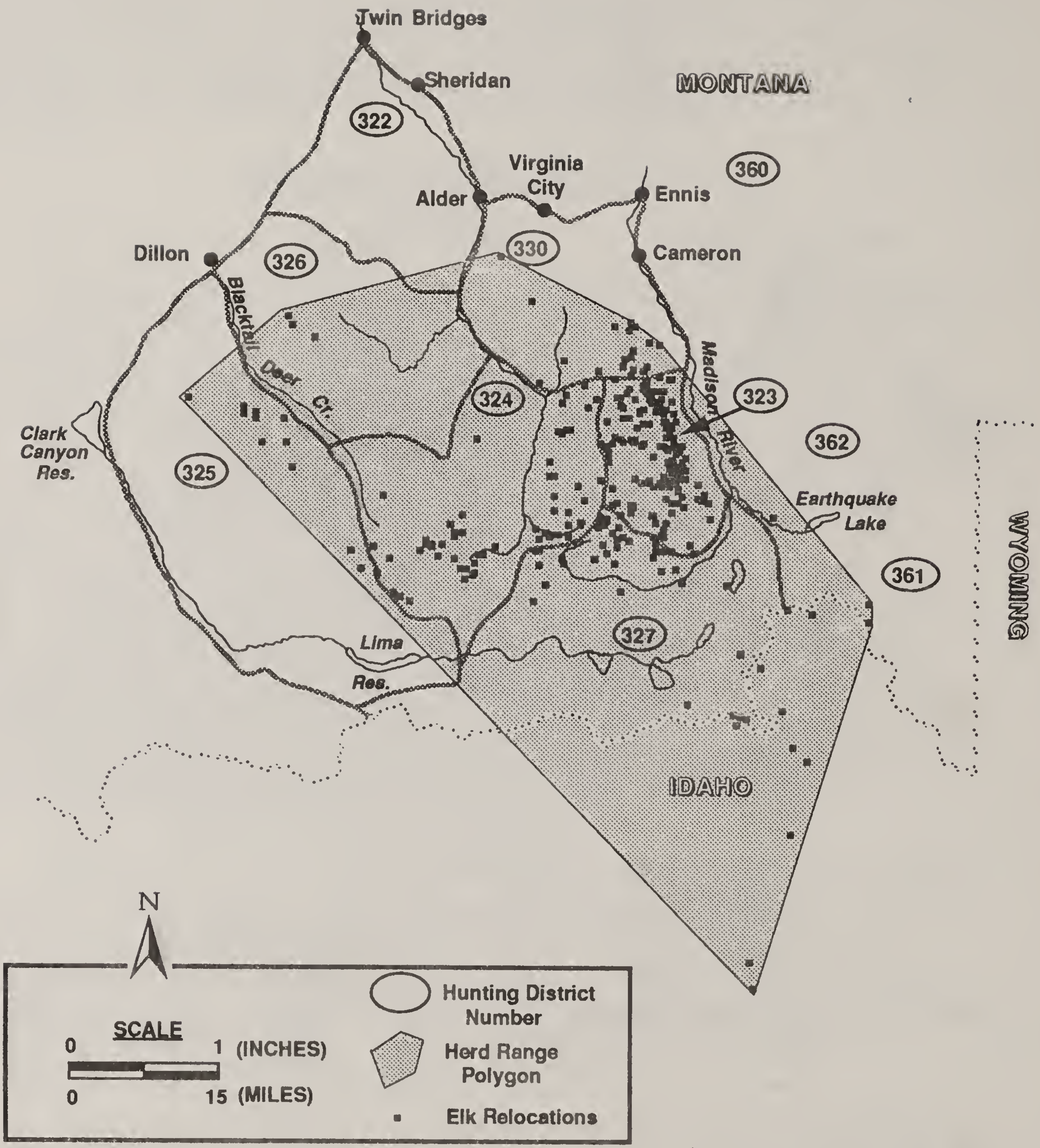

Figure 19. Yearlong distribution of 59 adult male elk marked on the Madison-Wall Creek Game Range based on 424 relocations made from March 1984 through 30 June, 1990.

### Blacktail Game Range elk

Yearlong distribution of 1,581 relocations of 64 adult female elk marked on the BTGR (Fig. 20) encompassed 2,725 $mi^2$ (7,059 $km^2$). The majority of locations were within HD 324. Other significant areas of summer-autumn distribution included the upper West Fork of the Madison River, Long and Fish Creeks, and the Centennial Mountains of Montana and Idaho from about Hellroaring Canyon to Jones Creek. Locations in the Centennial Mountains were mostly west of those recorded for WCGR females (Figs. 18 and 20).

There was considerable interchange during winter between BTGR elk and Robb-Ledford (R-L) elk (Fig. 20). A few animals marked on the BTGR moved to the WCGR to winter (Fig. 20). Summer-autumn locations southeast of Earthquake Lake (Fig. 20) were from one female that changed wintering residence to the WCGR.

Yearlong distribution of 188 relocations of 14 adult males marked on the BTGR (Fig. 21) encompassed 1917 $mi^2$ (4967 $km^2$). Most relocations were within HD 324, but many were also located in the upper West Fork of the Madison River. Locations in Idaho southeast of Henrys Lake (Fig. 21) were the result of one bull that summered and wintered there. Additionally, one bull dispersed to the Madison Range (Fig. 21) where he was shot. Too few bulls have been marked on this winter range to adequately map herd distribution.

### Cherry-Morgan Winter Range Elk

Yearlong distribution of 198 relocations of 31 adult females marked on the Cherry-Morgan winter range (C-M) (Fig. 22) encompassed 1403 $mi^2$ (3635 $km^2$). Most relocations were within HD 330, but many elk spent summer and autumn within HDs 323 and 324. Substantial winter interchange occurred with the WCGR elk (Figs. 18 and 22).

### Robb-Ledford Winter Range Elk

Yearlong distribution of 237 relocations of 21 adult female elk marked on the R-L winter range (Fig. 23) encompassed 814 $mi^2$ (2108 $km^2$). One of these females spent part of a winter on the BTGR, but most remained within the R-L wintering area. Most summer-autumn relocations were northeast of a line between the Notch and Corral Creek. No use of Peterson Basin and Lawrence Creek areas was indicated, but substantial use was made of the west slope of the Gravellys in the Upper Ruby area (Fig. 23). These limited data suggested that there may be a northern segment of the R-L population relatively distinct from the BTGR

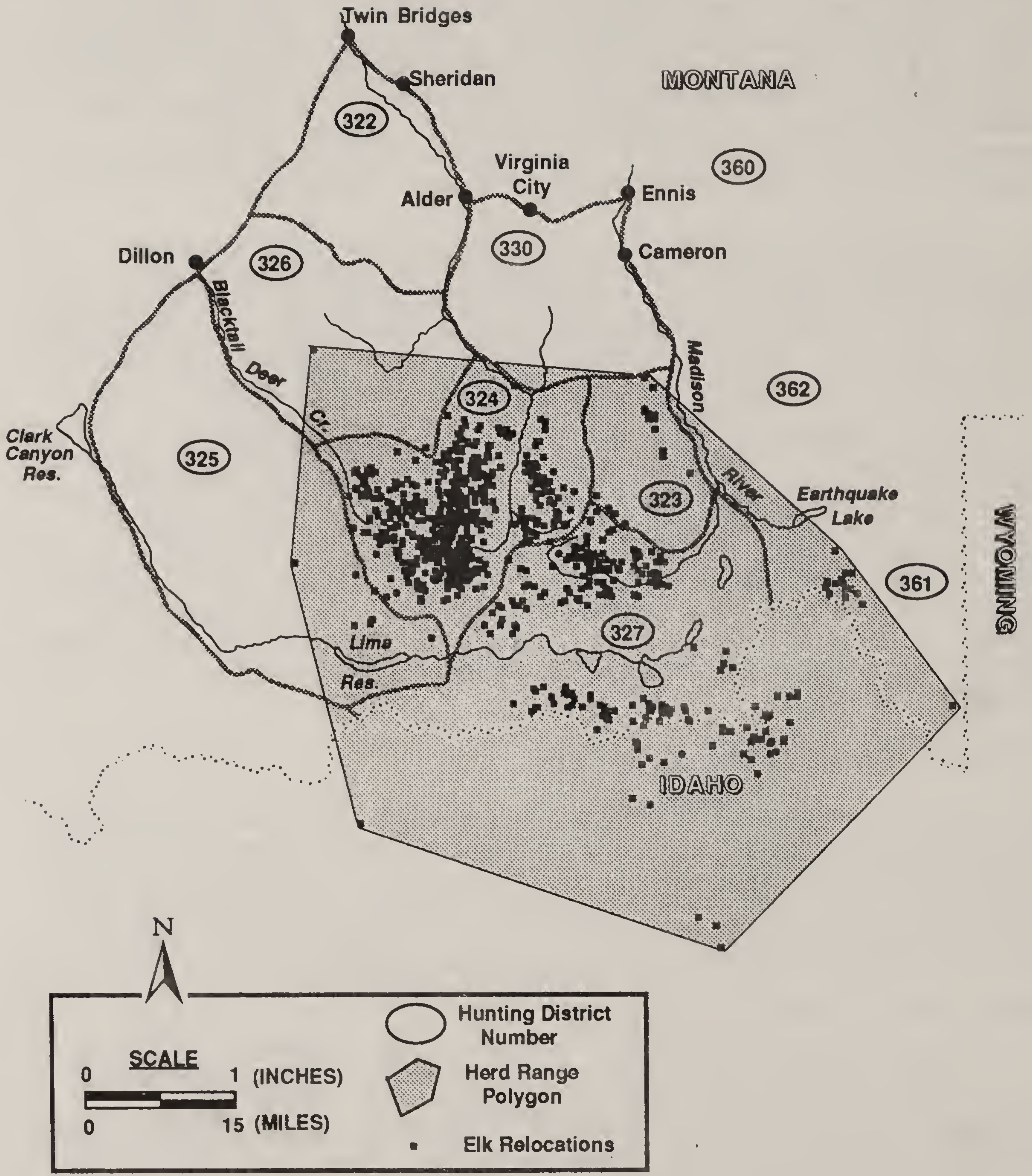

Figure 20. Yearlong distribution of 64 adult female elk marked on the Blacktail Game Range based on 1,581 relocations made from March 1986 through 30 June, 1990.

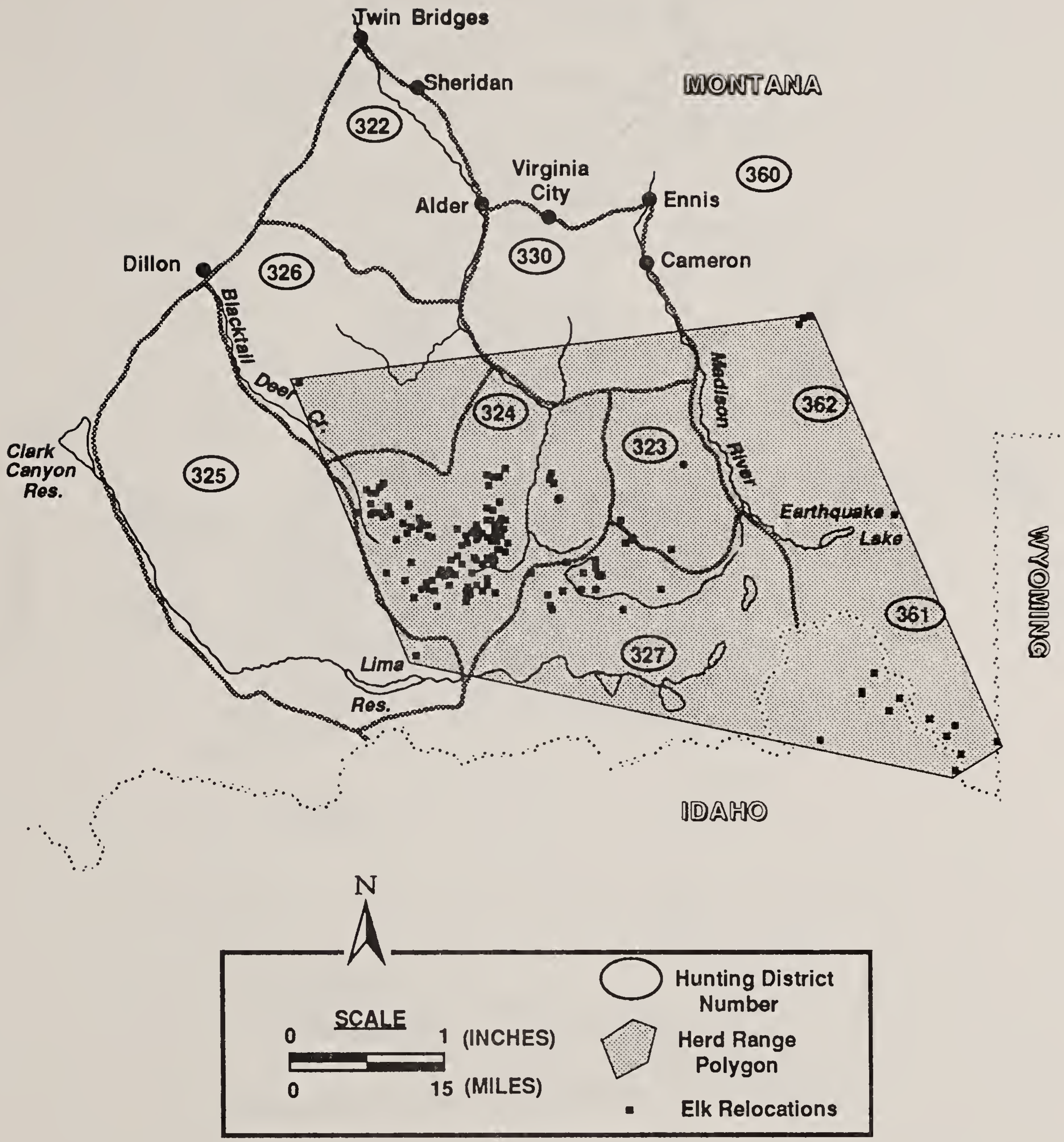

Figure 21. Yearlong distribution of 14 adult male elk marked on the Blacktail Game Range based on 188 relocations made from March 1986 through 30 June, 1990.

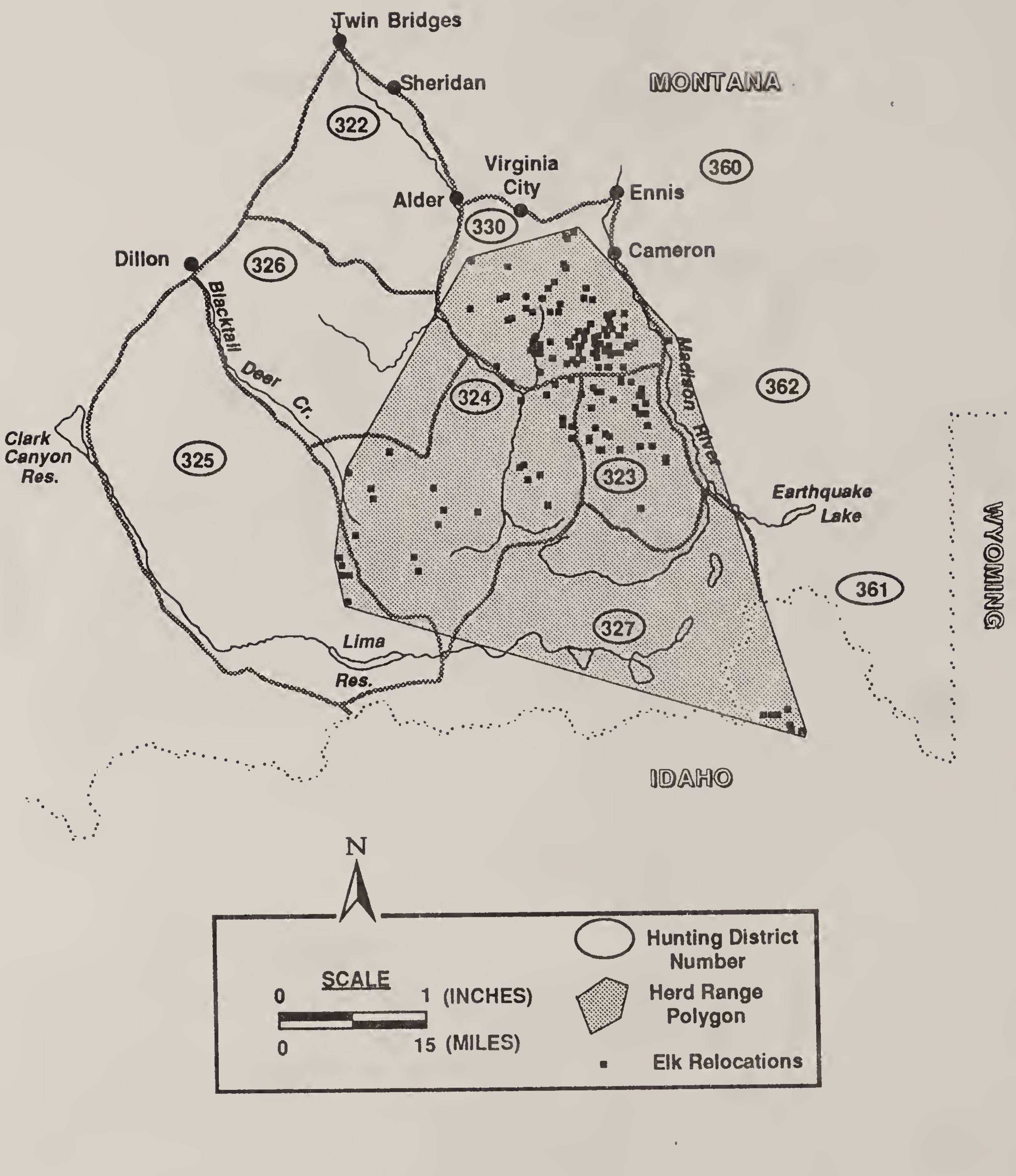

Figure 22. Yearlong distribution of 31 adult female elk marked on the Cherry-Morgan winter range based on 198 relocations made from March 1985 through 30 June, 1990.

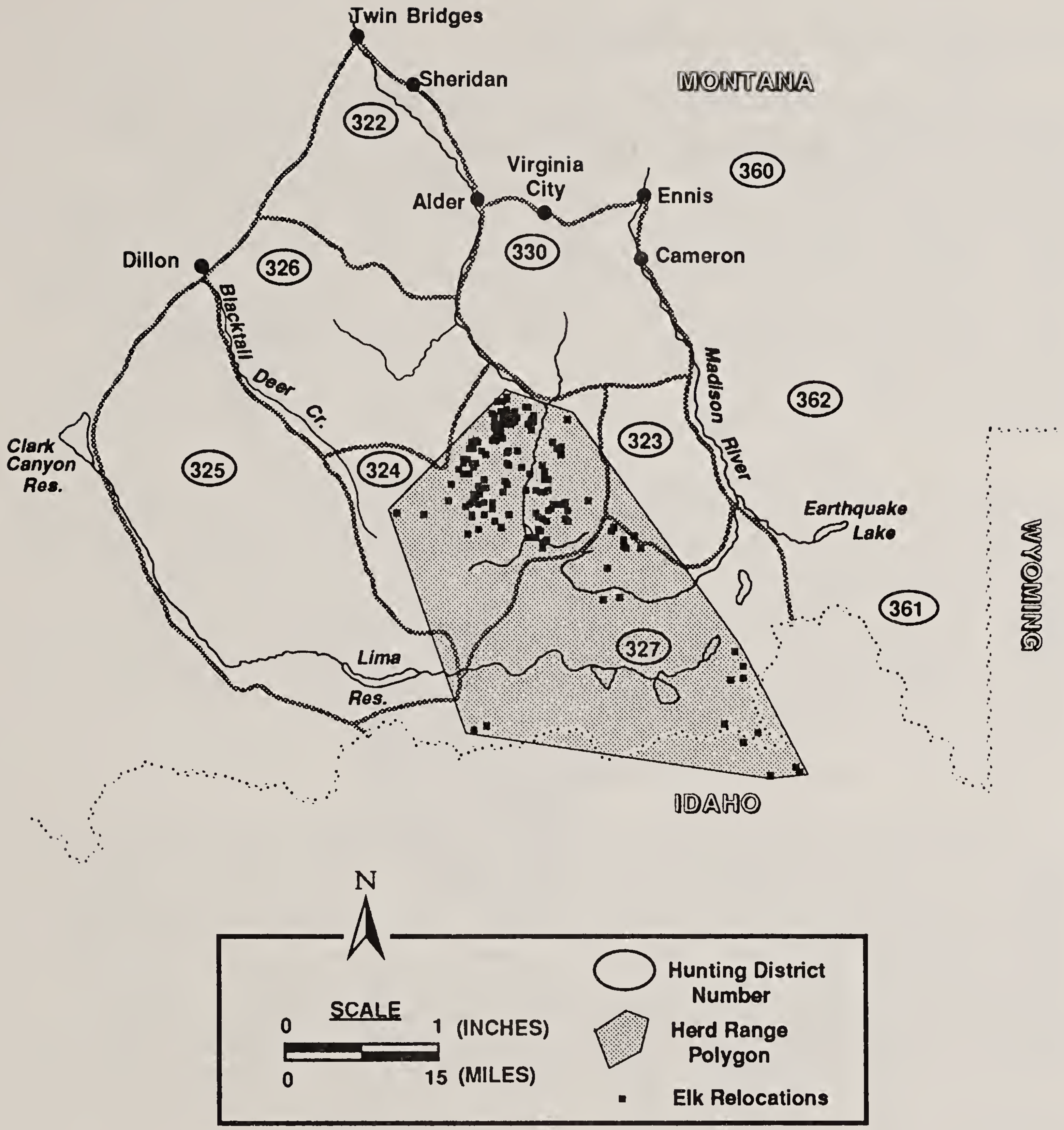

Figure 23. Yearlong distribution of 21 adult female elk marked on the Robb-Ledford winter range based on 237 relocations made from March 1989 through 30 June, 1990.

population, and another, southern segment that interchanged more freely with BTGR elk (Figs. 20 and 23).

### Basin-Sage Creek Winter Range Elk

Yearlong distribution of 115 relocations of 11 adult females marked on the Basin-Sage Creek (B-S) winter range (Fig. 24) encompassed 601 $mi^2$ (1557 $km^2$). Most summer-autumn relocations were in the Centennial Mountains of Montana and Idaho, west of those recorded for BTGR and WCGR elk. These summer-autumn locations of B-S elk were in the Camas Creek area of Idaho and an area generally ranging from Price Creek to Tipton Creek in Montana. The major wintering area was in the northwest part of the herd range around Basin and Sage Creeks (Fig. 24). During early winter and milder winters, however, many of these elk remained in the Centennials in the vicinity of Price Creek and Corral Creek.

We were somewhat surprised that these 11 elk were not spread more widely. Limited evidence from past marking, however, indicated a similar distribution pattern. For 5 females and 1 male marked in Basin Creek between 1978 and 1981, known summer-autumn locations included West Camas Creek, Monida Creek, and Little Creek in Idaho and Corral Creek in Montana. These earlier elk also spent portions of the winter in both Basin-Sage Creeks in HD 325 and Corral Creek in the Centennials.

### Warmsprings Creek Winter Range Elk

Yearlong distribution of 136 relocations of 9 adult females marked on the Warmsprings Creek (WMS) wintering area (Fig. 25) encompassed 278 $mi^2$ (721 $km^2$). One female spent summer and autumn around Coal Creek and another around the head of Cascade Creek, but most spent the entire year near the winter range (Fig. 25). The Middle and South Forks of Warmsprings Creek were especially heavily used. A larger sample size would likely expand herd range somewhat, but overall distribution of these elk may be relatively limited.

### Discussion of Herd Ranges

Existing boundaries for HDs 323 and 324 are about the best that can be drawn to direct hunting impacts to herds wintering on the WCGR and BTGR, respectively. Although different boundaries could be drawn if only considering one wintering population at a time, the existing boundaries are a good compromise when considering all herd units.

Similarly, the existing boundary of HD 330 will confine most effect of permit levels in that area to elk wintering on C-M and the Greenhorn Mountains. Some impact will also

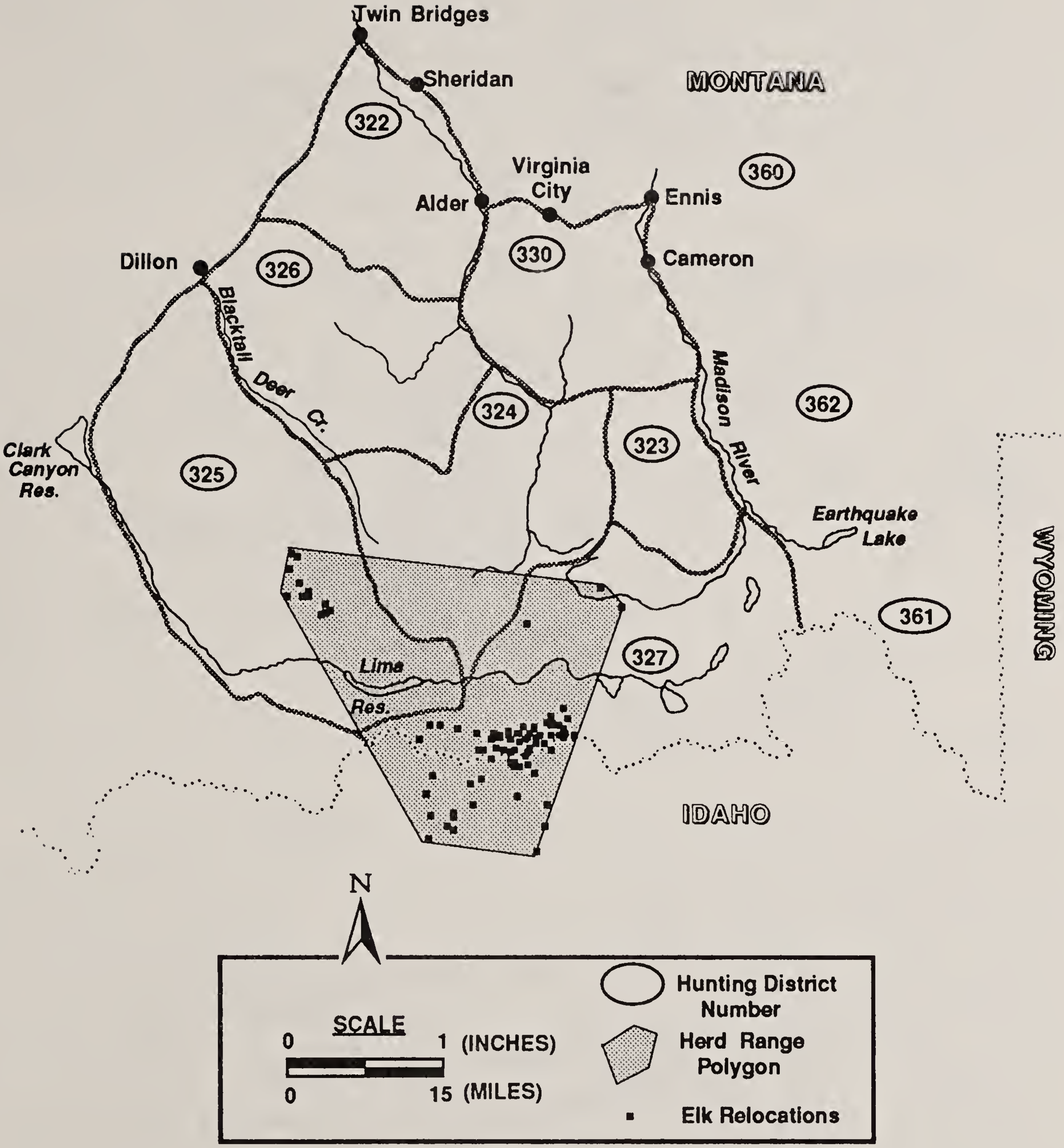

Figure 24. Yearlong distribution of 11 adult female elk marked on the Basin-Sage Creek winter range based on 115 relocations made from March 1989 through 30 June, 1990.

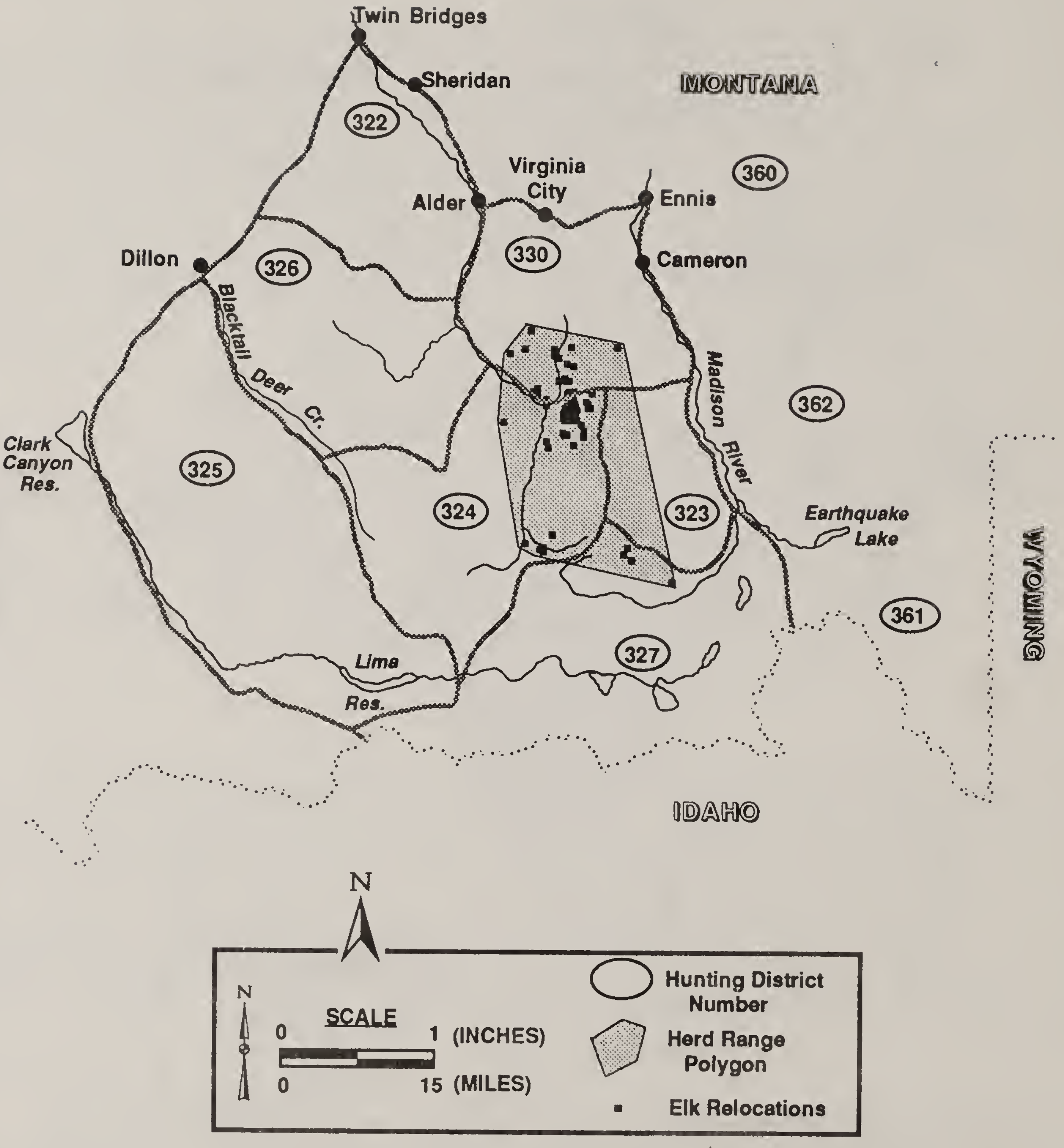

Figure 25. Yearlong distribution of 9 adult female elk marked on the Warmsprings Creek winter range based on 136 relocations made from March 1989 through 30 June, 1990.

be experienced by WMS elk, but they are also equally affected by regulations and permit levels in HD 324.

Significant overlap between BTGR and R-L elk makes directing hunting impacts to one segment or the other more difficult. However, if it were desirable to increase elk wintering in the R-L area while stabilizing or decreasing elk on the BTGR, making a portion of HD 324 antlerless permits valid only southwest of a line between the Notch and Corral Creek might help. Also, antlerless permits for the last portion of the season could be invalid north of the same line.

The migratory pattern of Gravelly-Snowcrest elk and their distribution into Idaho during autumn also presents special management challenges. There are very few year-long resident elk in HD 327 except during mild winters. Regulations for HD 327 will be directed toward long-distance migrants from several herd units. The effects of regulations and permit levels in HD 327 vary annually with weather and the timing of movements back to winter range. Significant use of the Centennial Mountains in both Montana and Idaho is made by WCGR, BTGR, and B-S elk (Figs. 18, 20, and 24). Early October general hunting seasons in Idaho impact these elk before Montana seasons start. Additionally, archery and muzzleloader seasons in Idaho coinciding with our general seasons also impact these elk. These long-distance migrants are not only affected by hunting seasons in 2 states, but usually by different regulations as well. Regulations in one state may sometimes negate the purpose of regulations in the other state.

The Montana side of the Centennial Mountains are fairly rugged and with limited access. During years with mild autumn weather, Centennial elk are often lightly harvested by Montana hunters. When severe weather forces them to move toward winter range during hunting season, they may be harvested more heavily. Similarly, the presence of elk in the northern portion of HD 327 is affected by weather and hunting pressure. Heavy early hunting pressure and/or severe weather during autumn will result in many of these elk moving into HD 323 or HD 324, toward the WCGR or BTGR, respectively. Thus, the effect of hunting regulations and permit levels in HD 327 varies annually with weather conditions. Coordination of hunting strategies with the Idaho Fish and Game Department may be beneficial.

The west side of the Gravellys in the upper Ruby River valley is a very popular area for hunting. Information on elk distribution indicates that elk from all herd units except Basin-Sage Creek are located in this portion of HD 324 during the hunting season. This distribution pattern may be beneficial if trying to achieve general elk reductions but may reduce efficiency if trying to target hunting pressure to specific herds.

Reductions of the herd wintering in Basin-Sage Creek in HD 325 (Fig. 24) may be difficult if hunting pressure is not directed toward the southwest end of HD 327. Most of these elk do not usually move to HD 325 until after the hunting season. A major portion of management of the Basin-Sage Creek wintering herd must be conducted with permits in HD 327 and harvest management in Idaho or with late seasons in Montana.

Although bulls showed a general fidelity to herd range, tentative indications were that this was to a lesser degree than occurred for cows. If this is found to be true, bull management practices must be conducted over larger units of land than is possible for cows. The concentration of capture and marking on bull calves during winter-spring 1990 and in future years should help clarify options in bull management.

### Individual Home Range Patterns

The most typical home range pattern for adult females (Fig. 26) was a relatively small home range of 46 (ID = 92988) to 80 (ID = 91586) square miles within about 15 miles of the winter range. A substantial portion of the population, however, were long-distance migrants (Fig. 27) whose home range includes locations near the winter range and summer-autumn locations concentrated some distance from the winter range. In the cases of females 92088 and 92086 (Fig. 27), winter and summer ranges were separated by 35-50 airline miles. Migration often occurred rapidly enough that few relocations were made in between winter and summer range. Some transitional locations were usually adjacent to winter range. Total polygon home range sizes for these 2 long-distance migrants (Fig. 27) were 185 and 569 square miles, but little of the area between winter and summer range was used or used for long. Because some quality summer range is far from quality winter range, these long-distance movements are necessary for high populations and habitat fill. These movements and home range patterns also present special management challenges.

Most bulls have larger home ranges than females (Fig. 28). This may occur because of an overall lesser degree of fidelity to any one area. For example, bull 10187 (Fig. 28) was only relocated 24 times over 3 years but wintered in 3 different areas during that time. Total polygon home range for bull 10187 was 946 mi$^2$ and for bull 10788 was 329 mi$^2$ .

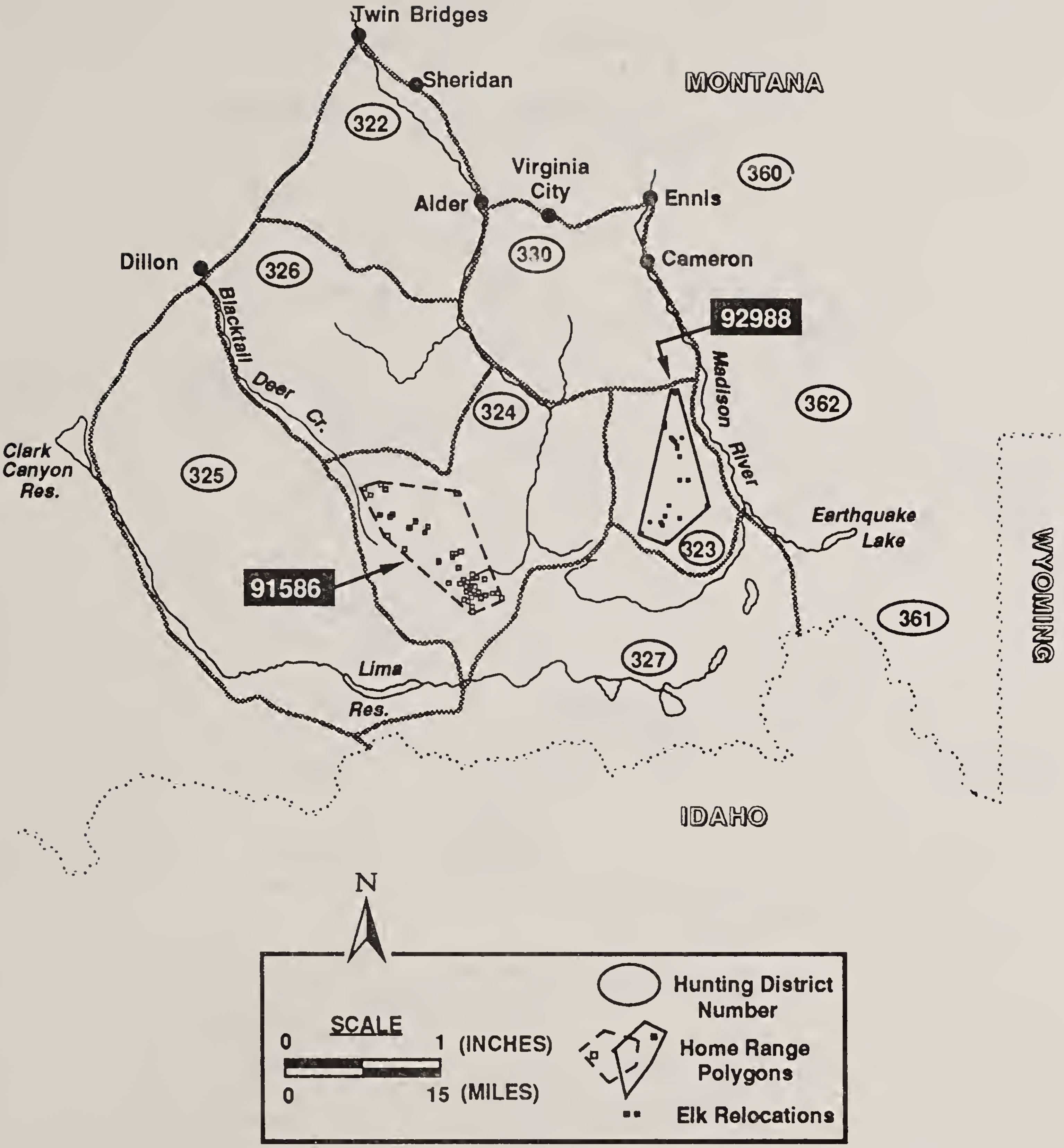

Figure 26. Typical life home range patterns for a Blacktail adult female elk (91586) and a Wall Creek adult female elk (92988).

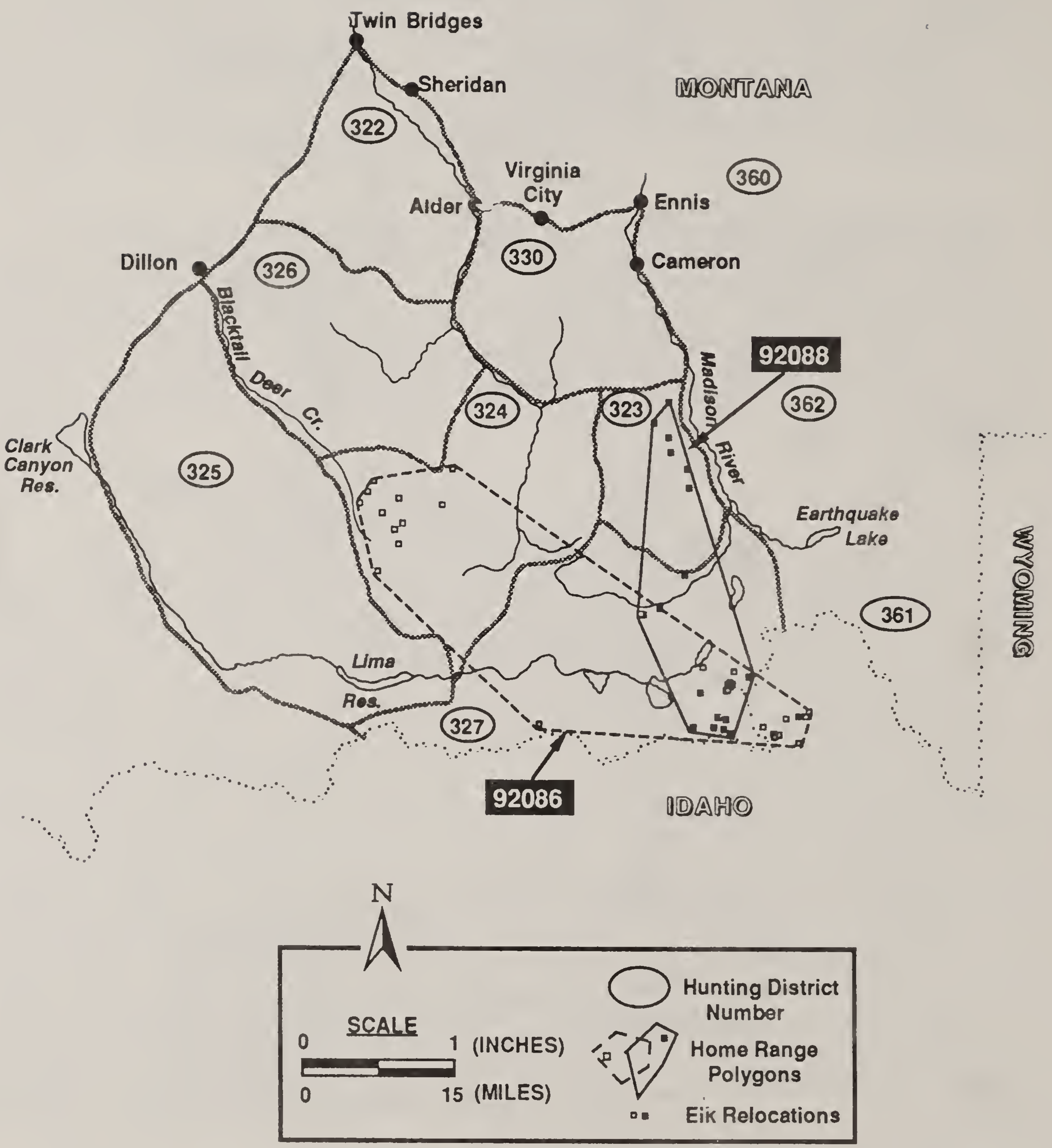

Figure 27. Life home range patterns for a Blacktail long-distance migratory adult female (92086) and a Wall Creek long-distance migratory adult female (92088).

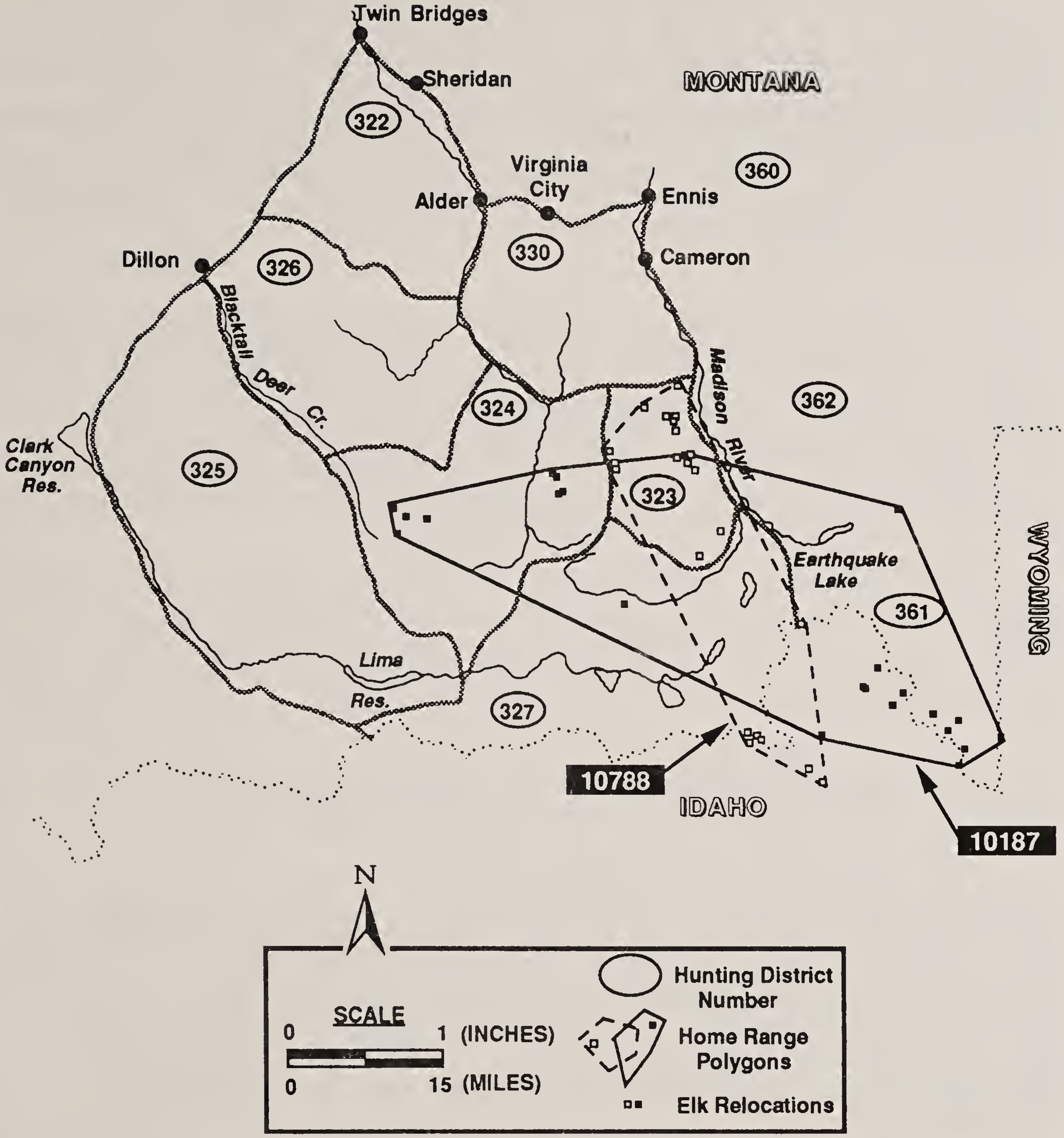

Figure 28. Typical life home range patterns for bulls marked on the Blacktail Game Range (10187) and the Wall Creek Game Range (10788).

## Hunter Opinion Survey

In 1984, 3 years after the first BAB regulation was implemented, an opinion survey was sent to hunters who indicated at check stations that they would respond to the mailing. Some results of this survey were described by Lonner and Schladweiler (1986). A similar survey, including additional questions, was sent to hunters expressing interest at 1989 check stations. Responses to the same questions asked in both 1984 and 1989 (Table 20) indicated relatively small changes as additional years of BAB regulations passed.

For 1989, the ages of hunters ranged from 14 to 74 and 97.5% were males, similar to 1984. Non-residents made up 3.6% of the sample, which was less than the 12% in the sample in 1984. Respondents were from 46 Montana towns throughout the state. Butte area hunters comprised 25.6% of the sample, Bozeman and Dillon area hunters comprised about 13% each, and a combination of smaller towns surrounding the Gravelly-Snowcrest range comprised 11%.

Years hunted ranged from 1 to 60 with about half having hunted for 15 years or less and half 16 years or more. Number of elk killed in Montana ranged from zero to 35; 12.7% had never killed an elk and 61.6% had killed 1-10 elk. Days hunted ranged from 1 to 32; 67% hunted 8 days or less.

Thirty-seven percent of the sample in 1989 had killed an elk compared to 20% in 1984. Successful hunters responded at higher rates than unsuccessful hunters.

The following percentage of hunters spent at least some time hunting by use of the following: vehicle 59%, vehicle with limited travel on foot 21%, foot travel 88%, horseback 23%, trailbike less than 1%, ATV (3 or 4 wheelers) 10%, and snowmobile 6%. The composite percent time by each method for all hunters in the sample was: vehicle 14.7%, vehicle with limited travel on foot 8.3%, foot travel 62.1%, horseback 12.2%, trailbike less than 1%, ATV 1.9%, and snowmobile 1%.

Similar to 1984, very few in the sample paid for outfitter services. In 1989, the only service paid for was horse rental (1.2% of the sample).

Twelve percent of the 1989 sample also hunted elk in the Gravelly-Snowcrest range by archery. In 1984, 10% of the sample had also hunted by archery.

Table 20. Responses of hunters during 1984 and 1989 to questions asked about their hunting experience in the Gravelly-Snowcrest Mountains.

| | 1984 | 1989 |
|---|---|---|
| Number of Respondents | 280 | 249 |
| % of Hunters that were males | 97.9 | 97.5 |
| % Nonresidents | 12.0 | 3.6 |
| % that killed an elk | 20.0 | 37.0 |
| % that also archery hunted | 10.0 | 12.0 |
| Quality of hunt (1=poor - 10=excellent) | 5.7 | 6.1 |
| % paying for full outfitter services | 0.7 | 0.0 |
| % paying for drop camp services | 1.0 | 0.0 |
| % paying for packing elk out | 1.0 | 0.0 |
| % paying for horse rental | 1.8 | 1.2 |
| % thinking that during the last 5 years total elk in the population has: | | |
| increased | 22.2 | 29.3 |
| been stable | 52.6 | 49.5 |
| decreased | 25.1 | 21.2 |
| As above, except total bulls: | | |
| increased | 23.7 | 20.9 |
| been stable | 37.7 | 43.6 |
| decreased | 38.7 | 35.5 |
| As above, except total branch-antlered bulls: | 21.3 | 19.6 |
| increased | 34.8 | 37.4 |
| been stable | 44.0 | 42.9 |
| decreased | | |
| % satisfied with opportunity to see a branch-antlered bull | 58.6 | 48.1 |
| % satisfied with killing any elk regardless of sex or age | 48.3 | 54.1 |
| % satisfied with existing regulations | 70.0 | 64.5 |

Generally, more people in the 1989 sample than in the 1984 sample thought the total elk population had increased. Fewer thought bull populations or branch-antlered bulls had increased. An increased percentage of 1989 respondents thought that bull populations were stable (Table 20). These opinions generally reflected what occurred in the elk populations (see earlier part of this report). Total elk populations continued to increase after 1984, but most of the increase in bull populations occurred between 1981 and 1984.

On a scale of 1 to 10 (1 = poor, 10 = excellent), hunters ranked the quality of their hunt an average of 6.1 in 1989 compared to 5.7 in 1984. In 1989, 40% ranked their hunt 1 to 5 and 60% 6 to 10. For 1984, the figures were 45% 1 to 5 and 55% 6 to 10. Similar to 1984, in 1989 successful hunters ranked the quality of their hunt higher (7.6) than unsuccessful hunters (5.1). When the higher percentage of successful hunters in the sample in 1989 than 1984 was taken into account, reported quality of the hunt did not change from 1984 to 1989.

In 1989, 48% of hunters were satisfied with the current opportunity to see branch-antlered bulls compared with 59% in 1984 (Table 20). In 1989, 54% were satisfied with killing any elk regardless of sex or age; for 1984, the figure was 48%. Sixty-five percent of hunters were satisfied with existing regulations in 1989 compared to 70% in 1984. These opinions reflect a slight deterioration in the acceptance of the BAB regulation between 1984 and 1989.

Eighty-four (33.7%) of 249 respondents had observed spike bulls (1x1) illegally or accidentally shot and left lay, or shot and taken home in 1989. Number of spikes observed shot and left lay ranged from 1 to 8 per hunter who had observed them. Forty-four percent had seen only 1 spike left lay. Fifteen (6%) of 249 respondents knew of 1 to 3 spikes shot and taken home. In total, 196 spikes were reported shot and left lay and 22 shot and taken home. Many of these were likely to be the same animals reported by several different hunters.

Hunters expressed the following opinion about the issue of illegal/accidental spike kill:

I think we just have to live with it - 7.3%
I don't believe it is a problem - 9.3%
I would like to try something to reduce it - 58.9%
Other - 24.4%

Hunter response to several proposed regulations addressing illegal/accidental kill of spikes was as follows:

I prefer the following definition of legal bull:

The current definition of branch-antlered bull - 40.9%
(A branch of at least 4 inches on at least 1 antler)
Branch in lower half of antler (brow-tined bull) - 21.9%
Four points on one antler (all at least 1 inch) - 28.9%
Other* - 8.3%
*the largest category within other was to return to any bull legal, including spikes - 5.4%

Major issues raised and comments by respondents are listed below in the order that they were most frequently mentioned.

1. more enforcement/larger fines for illegal kills
2. higher fines, more enforcement, and more restrictions on ATVs, snowmobiles, and other off-road vehicle travel
3. people holding cow tags should be restricted to shooting only cows
4. too much/too heavy grazing by domestic livestock
5. non-residents are the problem
6. open hunting back up to spikes legal (any antlered bull)
7. put all hunting on permit (including bulls)
8. more road closures
9. fewer road closures
10. off-road retrieval allowed during certain hours
11. more cow permits
12. do not allow bowhunting
13. more access to public land

There were also many other one-of-a-kind or infrequently mentioned comments.

## Effects of the Branch-antlered Bull Regulation

### Elk Populations

**The BAB regulation immediately increased the number and percentage of bulls observed on the winter range** (Figs. 6, 7, and 8). Bulls observed on the Blacktail winter range increased from about 2% of the population prior to the BAB regulation to about 9% in spring 1982 (Fig. 6). Some fluctuation occurred after 1982, but bulls have generally comprised between 8 and 10% of the Blacktail winter range population since 1982. Some increase in bulls as a percentage of the population was also observed at the Wall Creek winter range (Fig. 7), even during spring 1982 and 1983 when HD 323 remained open for antlered bull harvest. A portion of the bulls wintering at Wall Creek resided in HD 324 during the hunting season and thus were also affected by the BAB regulation. A further increase in the percentage of bulls observed on the winter range occurred in spring 1984 after implementation of BAB regulations in HD 323, 326, and 330 (Fig. 7). Bulls observed on the Wall Creek winter range have generally remained within a range of 7-10% of the population since 1984.

Two year old and older bulls observed on the winter range increased from almost none to about 1% of the population on the Blacktail winter range (Fig. 6) but have stabilized at that level. The percentage of the population comprised of 2+ year old bulls observed on the Wall Creek winter range appeared to be unaffected by the BAB regulation (Fig. 7).

**The BAB regulation increased the number of 2-year-old breeding bulls, but did not increase age or size beyond that.** The percentage of harvested branched bulls with 6 antler points on at least 1 side has not increased with time (Fig. 11). Similarly, the age of those harvested bulls 2 years and older has not increased with time (Fig. 29). The age of harvested bulls increased by about 1 year with the change from antlered bull to branch-antlered bull regulations. Under antlered bull management, about 80-85% of the harvest was yearling bulls. Under branch-antlered bull management, about 75-85% of the harvest was of bulls 2 years and older. Hunting pressure during most years was great enough that little escapement was possible for any legal bull.

**There was no evidence that average age or antler size of branch-antlered bulls increased in more secure habitat than occurred in the Gravelly-Snowcrest Mountains.** For HDs 301, 302, 311, 318, 319 and 341 combined, in years prior to the effects of BAB regulations (1985-87), the percentage of

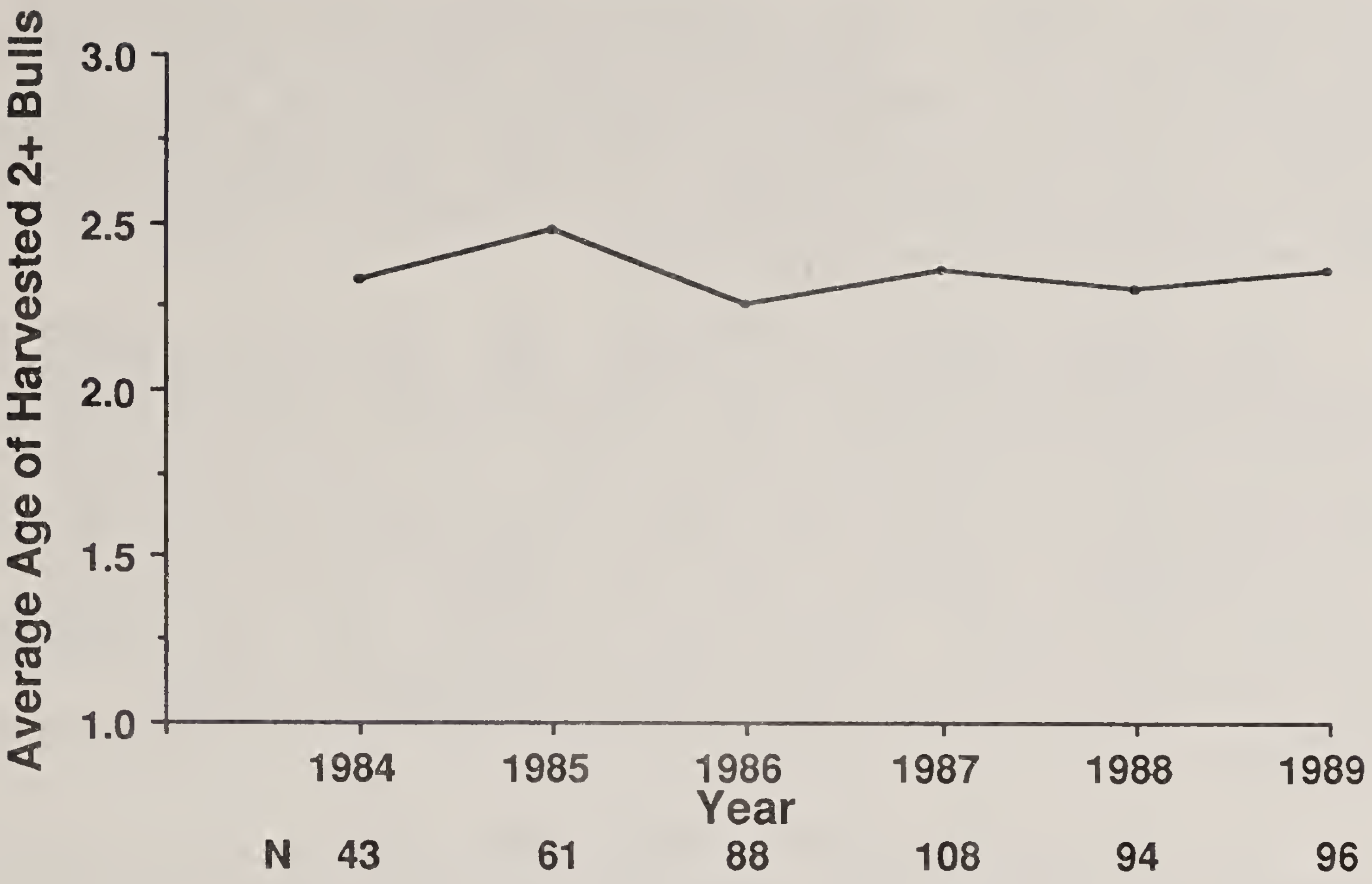

Figure 29. Average age of 2+ year old bulls harvested in Gravelly-Snowcrest hunting districts, 1984-89.

BABs harvested that had 6 points on at least one side was 16.4, 25.2 and 20.6, respectively. After the effects of BAB regulations, that percentage was 18.4 in 1988 and 20.8 in 1989. Similarly, for the Gallatin and Madison Ranges (HDs 310, 360, 361, and 362), 32.8 and 34.6 percent of harvested branch-antlered bulls had 6 points on at least one side in 1985 and 1986 prior to effects of the BAB regulation. That percentage was 25.0 in 1987, 31.1 in 1988, and 27.8 in 1989. The percentage of BABs that had 6 points on at least one side may have actually declined slightly. It is possible that with spikes not being shot, more bulls are harvested at 2-years-of-age and fewer survive to older age classes than under antlered bull management.

For 4 HDs (328, 329, 331, and 332) that remained antlered bull legal, the percentage of branch-antlered bulls harvested that had 6 points on at least one side remained higher than in the Gravelly-Snowcrest area, but has been declining. That percentage was 21.6 in 1986, 20.8 in 1987, 18.4 in 1988, and 16.0 in 1989. The percentage of 6 point antlers on all bull elk harvested, including spikes, for these HDs was 13.3 in 1986, 14.2 in 1987, 10.0 in 1988, and 7.9 in 1989. Hunting pressure in these HDs may be increasing enough to have started reducing the average age of harvested bulls. Since 1986, the number of hunters in HDs 328, 329, 331, and 332 has increased by 39% while the number of hunters in Gravelly-Snowcrest districts increased by 19%. The increasing number of areas with restrictions on hunting of bulls may be resulting in increased pressure on the remaining antlered bull areas.

**BAB regulations will increase bull survival by about 1 year on heavily hunted areas where very few bulls (<5%) are in wintering populations.** The effect of BAB regulations in areas of greater habitat security and with an existing older age structure for bulls is less clear. It appeared that average age and antler size may be declining on these areas. It is possible, however, that this decline would have occurred at an even faster rate had those area remained any antlered bull legal. It is also probable that the remaining any antlered bull areas are facing increased hunting pressure because most surrounding HDs have more restrictive seasons.

**We could not document a convincing relationship between numbers of breeding bulls and calf production and survival.** Unfortunately, many types of data were not available for the late 1970s and early 1980s. For example, data on pregnancy rates were available only from 1984 to the present. Pregnancy rates were high throughout that period. Pregnancy rates were slightly lower in spring 1984 and 1985 than later years (Fig. 12), but this did not necessarily coincide with lower than usual numbers of breeding bulls in both spring 1983 and 1984 (Figs. 6 and 7). Breeding by yearling bulls could result in high pregnancy rates but also a high proportion of late conceptions and late born, poor surviving calves. We do not have data on fetal age, but have observed very few late born calves during July surveys or at check stations.

Calf survival as measured in spring (t) must be compared to bull numbers 2 springs previous (t-2) to test for direct relationships. For example, increased numbers of bulls produced by the first BAB season in 1981 are first detected in spring 1982 classifications (Fig. 6). This increased number of bulls first breeds in autumn 1982. That calf crop is born is June 1983 and survival is recorded in spring 1984. The breeding effect of increased numbers of bulls surviving the 1981 hunting season is not measurable until spring 1984.

Data in Figure 30 are from Figures 6 and 7, but are appropriately offset as described in the preceding paragraph to display the relative size of the breeding bull

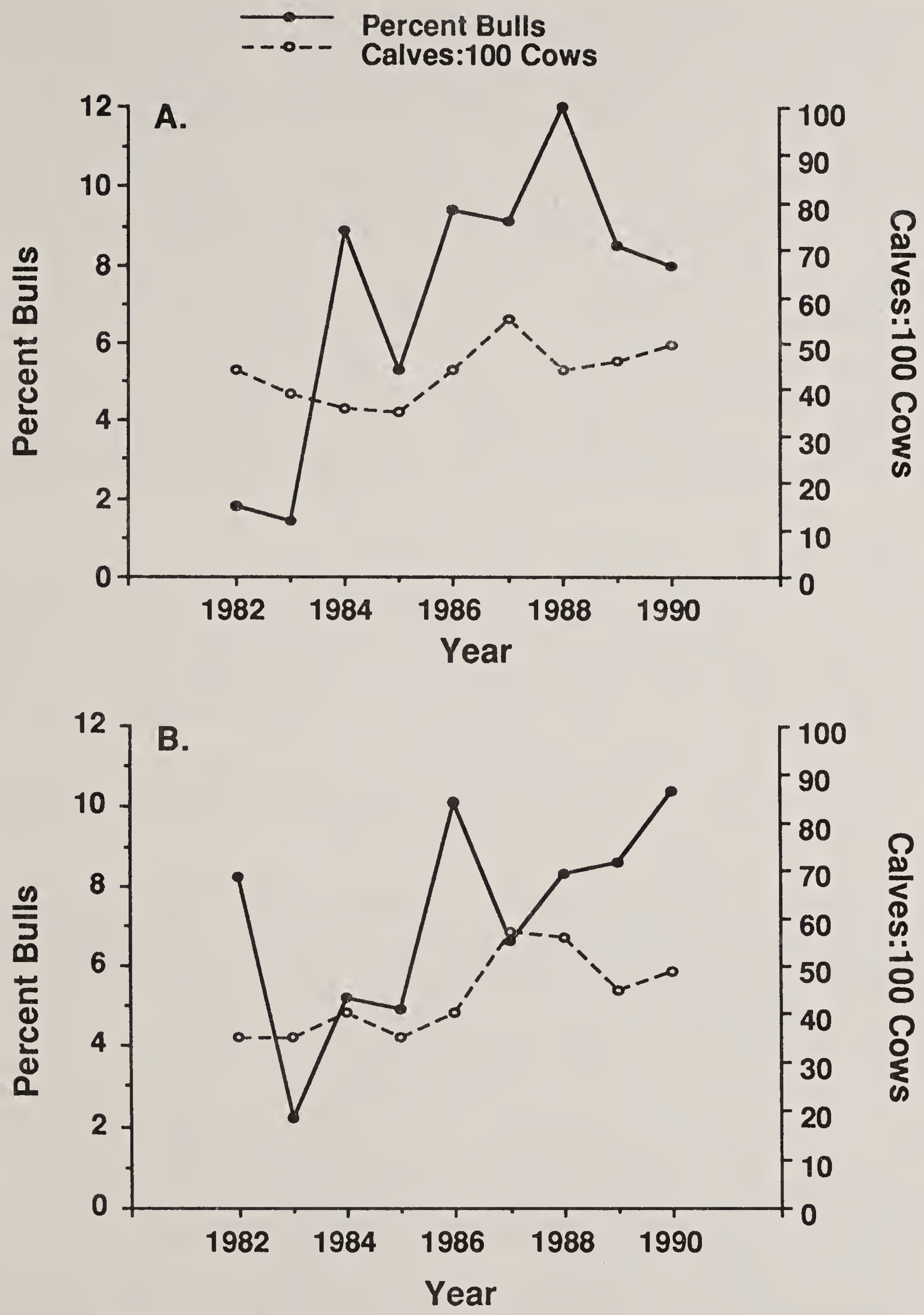

Figure 30. Size of the 2+ year old breeding bull population at the Blacktail Game Range (A.) and the Wall Creek Game Range (B.) in relation to observed calves:100 cows produced by that breeding cohort.

cohort in the year of the calf crop it produced. There was no clear direct relationship between size of the breeding bull cohort and the calf crop it produced. Correlation coefficients were r=0.33 (P=0.40) for the Blacktail area and r=0.43 (P=0.26) for the Wall Creek area. Considering the wide-ranging nature of bulls, data from both areas were combined. This resulted in a correlation coefficient of r=0.67 (P=0.05) indicating a possible relationship between breeding bull numbers and calf survival. However, the marginal nature of the relationship and the scatter of points made it difficult to rule out an only coincidental relationship. One of the problems with these "tests" is that on an area-wide basis, only 1 year (autumn 1981) provided a level of breeding branch-antlered bulls that was less than 5% of the population. Thus, despite the stated objectives of the study, little data was available on calf production associated with very low numbers of breeding bulls.

The gradual, overall rising trend of calf survival on this area since 1980 has coincided with an increasing trend in number of breeding bulls but may well be coincidental. No increasing trend in calf survival has been noted in HDs 340 or 380 despite an increase in bull:cow ratios from below 5:100 to above 10:100 (M. Frisina and R. DeSimone, personal communication).

Tests of the effect of size and age of the breeding bull population on calf production and survival have not been adequate for definite conclusions.

**A variety of information indicated that varying degrees of illegal mortality of spike bulls occurred concurrent with the branch-antlered bull regulation in the Gravelly-Snowcrest Mountains.** Thus, although the number of bulls observed on winter range increased, it did not meet anticipated levels. Similarly, number of bulls harvested declined from peak levels and stabilized at a lower level despite an increasing total elk population. This did not result from greater escapement by 2 year old bulls because average age of branch-antlered bulls did not increase. Information from marked animals and reports by hunters also indicated that illegal mortality of spikes occurred.

A comparison of rates of increase in bull harvests and total populations between the Gravelly-Snowcrest area and 4 HDs that remained legal to any antlered bull (AB) also indicated that illegal mortality of spikes was probably a major problem under BAB management (Table 21). In the AB hunting districts, harvest of total bulls (mostly yearlings) continued to increase along with total population while bull harvest declined in the Gravelly-Snowcrest area despite

Table 21. Relative rates of increase for bull harvest and population numbers in the Gravelly-Snowcrest Mountains which switched to branch-antlered bull (BAB) management compared to four hunting districts that remained any antlered bull (AB) legal.

| Wall Creek - Blacktail Game Range Areas (Gravellys) | | | | |
|---|---|---|---|---|
| | AB 1971-75 | AB 1976-80 | BAB Implemented 1981-83 | BAB 1984-88 |
| Ave. min. pop. est. | 1,476 | 2,135 (+45%) | 2,843 (+33%) | 3,052 (+7%) |
| Ave. bull harvest | 428 | 641 (+50%) | 604 (-6%) | 594 (-2%) |

| HDs 328, 329, 331, and 332 (antlered bull throughout) | | | | |
|---|---|---|---|---|
| | 1971-75 | 1976-80 | 1981-83 | 1984-88 |
| Ave. min. pop. est. | 941 | 1,279 (+36%) | 2,160 (+69%) | 2,631 (+22%) |
| Ave. bull harvest | 291 | 372 (+28%) | 482 (+30%) | 608 (+26%) |

increasing elk populations. Increased numbers of recruited calves in the Gravellys were not reflected in increased reported legal kill.

The BAB regulation in the Gravelly-Snowcrest Mountains resulted in increased numbers of yearling bulls on the winter range and increased numbers of 2-year old breeding bulls. We could not clearly determine whether this increase in 2-year old breeding bulls affected calf production and survival. Probable illegal mortality of spike bulls resulted in reduced reported legal harvest of bulls compared to areas with AB regulations.

## Hunters and Hunting

The number of hunters declined by about 20% in the first year that BAB regulations were implemented in one hunting district. There may have been an existing declining trend because hunter numbers had declined 14% during the prior year concurrent with an AB regulation. During the second year of BAB regulations, hunter numbers rebounded by 16% and have roughly stabilized since then. No further declines in hunter numbers were recorded when additional districts converted to BAB management in 1983 and 1987.

Except for 1983, hunter success rates for bulls did not decline with BAB regulations, possibly because of the somewhat reduced number of hunters compared to peak levels in 1979. Actually, hunter success rate for bulls was generally higher under BAB regulations (8.6 - 13.9%, $\overline{X}$ = 10.7) than under AB regulation (6.7 - 11.0%, $\overline{X}$ = 8.8).

As discussed earlier, total bull harvest in areas with BAB regulations declined from the peak that occurred under AB regulations. At least some of this decline would have occurred under continued AB regulations because of low calf recruitment. However, if calf recruitment would have also increased recently under AB management as well, perhaps total bull harvest would have increased more in recent years.

The BAB regulation was applied in the Gravelly-Snowcrest Mountains because of concern that low numbers of breeding bulls might have been the cause of low calf recruitment. Hunter acceptance of this regulation was variable, but opinions were generally positive by the second year. This resulted in pressure by hunters to apply the BAB regulation to other areas regardless of calf recruitment rates. In 1984, most hunters expressed positive attitudes about the BAB regulation (Table 20). Hunter attitudes remained generally positive in 1989, but some degree of increased dissatisfaction was apparent (Table 20).

Increasing hunter dissatisfaction may have been the result of several factors which, in combination, resulted in increased illegal mortality of spike bulls. Expectations of hunters were not being met. Although the MDFWP cautioned hunters that few bulls over 2 years of age were expected to be harvested, many hunters expected or hoped that older and larger bulls would be produced by BAB management. These older bulls were not produced. On the other hand, many hunters were quite pleased with the increased harvest of raghorn bulls. Also, implied within the regulation is that after the first year of implementation, total bull harvest should equal former levels owing to carryover of spike bulls to the 2 year old age category. This did occur during the second year of BAB regulations (Fig. 13). After that, however, total bull harvest remained lower than previously. At least initially, this was substantially the result of low calf recruitment. Illegal mortality of spikes may have become increasingly important and observations by hunters of this illegal mortality, including animals shot and left, increasingly reduced the quality of hunting experience. This increased illegal mortality may have partially resulted from the frustration by some "hunters" about continued low numbers of legal bulls.

Gradual implementation of the BAB regulation over 6 hunting districts, resulting in "alibi areas" and confusion with boundaries, may have also contributed to illegal mortality. However in HD 380, which is relatively isolated from other populations, illegal mortality of spikes was also relatively high during the one year in which BAB regulations were in effect (38%, R. DeSimone, personal communication). Perhaps frustrated expectations, low numbers of legal bulls, lack of support of the BAB regulation by some, and confusion about definitions all combined to produce illegal mortality and reduced legal harvest.

An attempt to reduce illegal mortality and increase the recruitment of 2 year old bulls is currently being tested. A new regulation (brow-tined bull) defines a legal bull as: Any elk having an antler or antlers with a visible point on the lower half of either main beam that is greater than or equal to four (4) inches long. This regulation essentially confines legal bulls to those 2 years and older with "raghorn" or better antlers. The objective of this regulation is to reduce the incidence of hunters shooting at yearling bulls and hoping that they are legally branched. Almost no yearling bulls will have a brow tine. This regulation, if successful, will result in survival to 2 years of spikes formerly illegally shot and also of branch-antlered (1x2, 2x2, etc.) yearlings that were previously legal game. Future reports will discuss the results of the brow-tined bull regulation.

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